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Determinants of Agricultural Growth in Indonesia, the Philippines, and Thailand

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Abstract

The introduction of new high-yielding varieties of cereals in the 1960s, know as the green revolution, changed dramatically the food supply in Asia as well as in other countries. Mundlak, Larson, and Butzer examine over an extended period the growth consequences for agriculture in Indonesia, the Philippines, and Thailand. Despite geographic proximity, similar climate, and other shared characteristics, gains in productivity and income differed significantly among the countries. The authors quantify these differences and examine their determinants.

Mundlak, Larson, and Butzer find that the new technology changed the returns to fertilizers, irrigated land, and capital, all of which proved scarce to varying degrees. Complementing technology-related changes in factor use were investments—public and private—driven in part by policy. The authors find that factor accumulation played an important role in output growth and that accumulations from policy-driven investments in human capital and public infrastructure were important sources of productivity gains. They conclude that policies that ease constraints on factor markets and promote public investment in people and infrastructure provide the best opportunities for agricultural growth.

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Determinants of Agricultural Growth in Indonesia, the Philippines, and Thailand

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1. Overview

INTRODUCTION

Can Asia feed itself? What changes have taken place in the process of economic growth? What role has agriculture played in the process of economic growth? What impact has growth had on income distribution? These questions have been dealt with in the various papers in this volume. In what follows, we deal with these questions by examining the determinants of agricultural growth and some consequences in Thailand, Indonesia, and the Philippines, from 1960s on.[1] The countries in question share some common attributes: they are located near one another and have similar climates; they all experienced relatively high rates of population growth (above 2 percent); the staple food is rice; and they all grow tree crops, the output of which is largely export oriented. At the same time, there are striking differences in their overall economic performance over the last three decades;[2] the growth rate of output (GDP) in the economy at large was 7.1 percent in Thailand, 6.4 percent in Indonesia, and only 3.6 percent in the Philippines (Table 1.1). The growth rate of agricultural output (GDP) was 3.69, 3.48, and 2.55 for the three countries respectively. Clearly, non-agriculture grew much faster than agriculture. The rates of growth of per capita output show even sharper differences, while in the Philippines per capita agricultural output barely grew; the rate was 1.46 percent in Thailand, and 1.42 percent in Indonesia. It thus appears that the Philippines have faced a real challenge of feeding a growing population. But it also faced a real challenge of raising the overall standard of living, by growing at the per capita rate of 1.1 percent, as compared to 4.87 and 4.33 percent in Thailand and Indonesia respectively. Thus, the Philippines lagged behind in its growth of agricultural as well as of total output. This apparent correlation between total and agricultural performance suggests that there are common factors that affect agriculture and non-agriculture.

Changes within agriculture

Table 1.2 summarizes the changes in agricultural output and inputs by sub periods. The country ranking of output follows the pattern observed in Table 1.1. The time pattern shows a decline in the output growth rate from 1980 on. The most drastic change took place in the Philippines, where the rate declined from 3.82 percent in the period 1961-80 to 1.38 percent in the period 1980-98. In this latter period, the growth rate was less than that of population growth.

[1] The actual period analyzed was determined by the data availability.

[2] For a discussion of country differences in physical environment and political history see Hayami (this volume). For a comparison of trade protection rates see Akiyama and Kajisa (this volume.)

Agricultural labor in our data set is a stock number, as explained in a later section. For the period as a whole, labor grew at a slightly lower rate than population; the difference indicates migration of labor to non-agriculture. The exception is Thailand in the boom period of the 1970s when agricultural labor grew at a rate of 3.75 percent. The determinants of the pace of migration are discussed in the chapter on migration. When the pace of migration is low, labor supply rises due to population growth, and labor productivity in agriculture tends to decline. We return to this below.

Land expanded at a slower pace than labor, and therefore the land-labor ratio declined (Figure 1.1). We differentiate between growths of irrigated and non-irrigated, or rainfed, land.[3] Irrigated land is more productive for a variety of reasons; it allows multiple crops per year, and in many cases it represents a better quality land. The irrigated land constitutes a small fraction of the total land (Figure 1.2). Its expansion requires investment in water supply and irrigation system; and therefore it is constrained by the availability of capital. Major projects are usually financed by public programs. In Thailand and the Philippines the pace of growth of irrigated land exceeded that of labor, and it resembled the rate of output growth. The pace in Indonesia was considerably slower. Indonesia seems to have faced the most severe capital scarcity. As shown in Figure 1.3, the capital-output ratio in Indonesia in 1961 was .07, much lower than in the other two countries. The situation changes as a result of the swift growth of capital. The fast growth of the capital stock resulted in convergence to the order of magnitude in the other two countries. Thus in 1996, the ratio was 0.84 in the Philippines, 1.2 in Indonesia, and 2.5 in Thailand. How does it compare with other countries? Mundlak (2000) presents empirical distribution of fixed capital-output ratio of 58 countries. The median of this distribution was 1.4 and 1.8 in 1970 and 1990 respectively. Our figures for the three countries include capital of agricultural origin in addition to fixed capital, and therefore the comparison is obscured.[4] With this reservation in mind, it appears that the capital-output ratio in the Philippines and Indonesia was below the sample median.

Fertilizers were the fastest growing input. As shown in Figure 1.4, the fertilizer-land ratio was lowest in Indonesia, which also had the lowest ratio of irrigated land (Figure 1.2). For the period as a whole, the growth rate was about 10 percent in Thailand and Indonesia and 5.4 percent in the Philippines. This growth reflects the introduction of new varieties that are fertilizer intensive, as well as the expansion of irrigated land and with it the extent of multiple cropping. In all three countries, the rate of growth decreased in the period after 1980. The change is particularly strong in Indonesia.

EMPIRICAL PRODUCTION FUNCTION

To obtain the contribution of the various inputs to output we estimate a Cobb-Douglas production function. In order to concentrate on the results and their economic meaning we defer the discussion of the technical aspects of the estimation, and the description of the variables to latter sections and to the country chapters. We just note that the dependent variable is the log of value added, not production. In this section we present a set of final results and concentrate on their meaning. The results appear in

[3] Rainfed land is calculated as the difference between agricultural land and irrigated land.
[4] The coverage of fixed capital data is not well-defined. For some comments on this subject, see Larson et al. (2000).

Table 1.3. The upper panel presents the input elasticities, and the lower panel presents the coefficients of what we refer to as state variables, discussed below. In a competitive market with full information, the elasticities should equal the factor shares, up to a stochastic error. If the countries use the same technology, the estimates should be quite similar, but they are not. This fact is essential for the understanding of the discussion in this paper.

The elasticity of irrigated land in Indonesia is 0.46, which is quite high. Rainfed land was most important in the Philippines with an elasticity of 0.43. The sum elasticities of the two types of land varied in the range of 0.38 (Thailand) and 0.69 (Indonesia). The impact of the high elasticity of irrigated land in Indonesia will be noticed throughout our discussion. Two circumstances might be related to this result. First, a good part of the irrigated land is in Java, which is by far the most productive island. Second, the share of irrigated land in total land was smallest in Indonesia (Figure 1.2), which indicates that irrigated land was relatively scarce there.

There is more agreement in the estimates of the fertilizer elasticity, which varied between 0.06 and 0.084. To interpret this result, note that the dependent variable is the log of value added and not of production. In the computation of value added the cost of raw materials is deducted from total output. Profit maximizing firms cannot increase profits by changing the quantity of the raw material away from the optimal level (an example of the envelope theorem). The value added function can be viewed as a restricted profit function, in the sense that it provides the maximum value added given the restricted (fixed) inputs and the pertinent prices. This result implies that the coefficient of fertilizers should be zero, in the sense that there should be no functional distribution to fertilizers from value added. But this is not the case. We return to this below.

There is a considerable difference among the countries in the capital elasticity. It is particularly high in Thailand, where the land elasticity was lowest, and it is particularly low in Indonesia, where the irrigated land elasticity was highest. As shown in Figure 1.3, Thailand had the highest capital-output ratio, and Indonesia had the lowest one, and most of the time the difference was substantial. Finally, the labor elasticity was relatively low, in that labor is attributed to less than 20 percent of total output. The discussion of the results related to the state variables in the lower part of the table is deferred, so that we can continue the discussion of the meaning of the input productivity. We begin with the evaluation of the marginal productivity, or shadow prices.

SHADOW PRICES

The emphasis in the regression analysis has been on the explanation of the variations in output in terms of the changes in the inputs and state variables. The technical problems of the estimation are discussed below. We turn now to evaluate the economic meaning of the results. We begin with the evaluation of the marginal productivity, or the shadow price, of the various inputs. Recalling that output is measured in value, we can use the estimated elasticities to recover marginal value products, that is: $\partial y/\partial x_i = \varepsilon_j \, \bar{y}/\bar{x}_i$, where ε_j is an estimated elasticity associated with input j, and where inputs (x) and output (y) are measured at average levels. This measure of marginal productivity represents a shadow value, which, under perfect circumstances, equals the price of the input. The comparison of the shadow prices to actual prices is hindered by the limited information on factor prices. However, we can also calculate marginal rates of technical substitution, $\frac{\partial y/\partial x_i}{\partial y/\partial x_j}$. When factor prices ($w$) are available, say for x_j, we can check to see if the following identity approximately holds, $\frac{\partial y/\partial x_i}{\partial y/\partial x_j} = \frac{\partial y/\partial x_i}{w_j}$. We extend the discussion to a cross-country comparison of the shadow prices and to their changes over time. To facilitate the cross-country comparison, we convert the value terms to constant 1993 US dollars.[5] The average level of the shadow prices are presented in Table 1.4 for the sample period used for each country. The periods are not identical, but the degree of overlapping is substantial. In order to be able to trace the source of cross-country differences, we report the elasticity and mean value of the average productivity *(y/x)* in addition to the marginal productivity. This discussion is then followed up by the time pattern of the changes.

Land

The marginal productivity of irrigated land is 352 for Thailand 1971-95, 1001 for the Philippines 1961-98, and 2,288 for Indonesia 1971-98 (line A1 of Table 1.4). The values for Thailand and the Philippines do not vary drastically over time, but they rise considerably for Indonesia. These are the shadow values of the annual rent on irrigated land. Thus, there is a considerable difference in the order of magnitude of rent across countries. The estimates reflect the estimated elasticities and the average productivity. Outstanding in this comparison is the high elasticity for irrigated land in Indonesia. The extent to which this value is an accurate report of reality occupies our subsequent discussion. The average productivity of irrigated land is highest in the Philippines, but it is not much higher than the value obtained for Indonesia. The average productivity of irrigated land is by far lower in Thailand, which also has the lowest elasticity for irrigated land, and hence the low value of the shadow rent.

The shadow rent on rainfed land is 138 for Thailand and Indonesia and 363 for the Philippines (line A2). The cross-country comparison is affected by the conversion of the values from local currency to constant 1993 US dollars. To neutralize this effect, as well as others that influence the levels, we examine the ratio of the shadow rent on irrigated land to rainfed land. As mentioned, there are several reasons why irrigated land is more productive and the ratio of marginal products provides a measure of this difference. The results for Thailand and the Philippines are quite similar, 2.5 and 2.7 respectively (line C1). This is suggestive: at the margin, irrigated land is about 2.5 times as productive as rainfed land. The productivity of irrigated land relative to rainfed land is considerably higher in Indonesia. This reflects largely the high elasticity for irrigated land in Indonesia, which was alluded to above. The variability in the ratio of the averages of the two types of land, or equivalently the share of irrigated land in total land,

[5] The value data are reported in local currency in constant prices, 1985 for the Philippines, 1988 for Thailand, and 1993 for Indonesia. They are converted to US dollars using the exchange rate for these years: 18.607, 25.34, and 2087 for the three countries respectively. The result is then adjusted to 1993 values using the US GDP deflator: 1985=0.784, 1988=0.853, and 1993=1.00.

is not that large: it is quite similar in Indonesia and the Philippines, and about twice as large in Thailand. We return to the discussion of land below.

Capital

The marginal productivity of capital is an estimate of the shadow price of the user cost of capital consisting of interest rate, *r*, depreciation rate, *d*, and expected capital gain. Because we deal with long-term averages, we evaluate the result under the assumptions of zero expected capital gain. The results are 20 percent for Thailand, 15 percent for the Philippines, and 9 percent for Indonesia (line A4 in Table 1.4). On the whole, these results are highly suggestive.

In the case of the Philippines, we differentiated between two types of capital: machinery and capital of agricultural origin, mainly livestock and orchards. The former constitutes only about 2 percent of the latter, and therefore it is ignored in the discussion. It should be indicated, however, that the shadow price on machinery is extremely high; this reflects the very high average productivity of machinery due to the low value of the input[6]. The lowest marginal productivity of capital is obtained for Indonesia. The estimate in Indonesia varied considerably with time; it was high in the early years and it declined later on with the rapid increase in the capital stock in agriculture. We return to this below.

Labor

The marginal productivity of labor varies between 79 in Thailand to 160 in the Philippines (line A5). The big story here is not the cross-country differences, but rather the big gap between the marginal productivity of labor and the wage rate (also reported in Table 1.4). Note that the wage rates in Thailand and the Philippines are reported as daily wage rates.[7] We converted them to annual rates by assuming an average of 150 working days per year in agriculture of a person reported in the agricultural labor force. The assumption of 150 working days per year in agriculture is of course arbitrary. A substantially larger number would make the gap between the annual wage and the marginal productivity of even higher. By the same token, it would make the labor share unreasonably high. The difficulty in determining the annual wage stems from the fact that actual employment in agriculture is not reported, and we have to infer it from data on the agricultural labor force. Agricultural labor demand is seasonal, which causes less than full year employment in agriculture for rural labor. Labor time not spent in agriculture is spent in nonagricultural activities, including unemployment. For Indonesia, the data report annual wages, so that the problem of converting daily wages to annual wages does not exist, or it is disguised.[8]

The big difference between the estimated shadow price of labor and the wage rate may arise due to several reasons. First, the estimated labor elasticities are possibly biased

[6] A good example is the use of mechanical threshers that make possible a third crop for rice in some areas of the Philippines (Cuddihy, 2002).
[7] Nominal wage rates were deflated by the consumer price index to obtain real wage rates which were converted to $1993 following the procedure described in footnote 5.
[8] For Indonesia we deflated the nominal wages by the GDP deflator.

downward. Indeed the elasticities are by far lower than the respective labor shares, but this gap is another face of the same problem, and it might just as well arise due to an upward bias in the estimated labor shares. It is important to note that the gap is common to all the countries and that weakens the likelihood that the culprit is a big downward bias in the estimated labor elasticities. Second, workers classified as agricultural may devote a portion of their time to activities outside agriculture with the consequence that the size of the labor force in agriculture is considerably lower than the reported one.[9] In terms of our calculations, this is another way of saying that the average number of working days of a reported labor force in agriculture is less than 150 days. Third, the problem is not so much in the reported labor force, but in the mere fact that there is 'surplus labor' and disguised unemployment in agriculture. Fourth, the conversion of the wages from local nominal values to constant US dollars introduces annual variability in the country data due to the strength or weakness of the local currency. This problem is relevant mainly for Indonesia, and it is discussed in the country chapters. In any event, it cannot account for the big gap between the shadow wage and the calculated wage.

Fertilizers

As noted, the dependent variable of the production function is the log of value added and not of output. And for reasons discussed earlier, we would expect that the marginal productivity of fertilizers derived from the value added function should be zero. This is the textbook result.

The argument, however, is valid only for the homogeneous technology with competitive markets for both the product and the raw materials. When this is not the case, and the prices perceived by the farmers are different from those used in the national accounts, the argument does not apply any more. Specifically, when the supply of fertilizers is not perfectly elastic, the empirical coefficient of fertilizers reflects the shadow price of fertilizers, which is different from the average market price. In this connection, we note that the growth rate of fertilizer use in the three countries was considerably higher than that of the other variables. This suggests that the countries were closing a gap in the excess demand for fertilizers, which is inconsistent with the assumption of optimal use under perfectly elastic supply of fertilizers throughout the sample period. More evidence on this point is brought up in the subsequent chapters. The whole theoretical argument is further modified in the case for heterogeneous technology, which as explained below is the framework of this analysis. In this case, a change in factor supply causes an inter-technique movement. This is believed to be the force behind the continuous excess demand for fertilizers.[10]

In evaluating our results, the estimated marginal productivity of fertilizers in the value added function is referred to here as the distortion coefficient. In the textbook competitive model it would be zero, indicating no distortion. The distortion coefficient reflects the shadow price of the constraints that prevented farmers from reaching the optimal use of fertilizers. This is a measure of the excess demand at the ongoing prices.

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[9] It is well recognized that rural households often diversify their labor among several activities, some of which are off-farm. See Lanjouw and Lanjouw, 1995.

[10] Using household survey data, Larson and Plessmann (in this volume) estimate an elasticity of 0.09 for fertilizers and find the estimate robust under alternative model specifications.

This is considered here to be the main reason, but there may be others, such as a difference between the price of fertilizers used in the national accounts and the cost at the farm gate.

To see this consider the maximization problem, $\max_x L = py - wx + \lambda(x^c - x)$, where x^c is the constrained consumption of fertilizer. From the first order conditions we have $p\partial y/\partial x = w + \lambda$. The first order condition on the marginal value added function is $p\partial y/\partial x - w = \lambda$. If λ were to equal zero, the normal unconstrained first-order condition would prevail. When value added is used as the dependent variable in a regression, and x is constrained, λ is the deviation of the first order condition from the standard competitive model, and is referred to as distortion. It is measured in units of value added per unit of x. To normalize it, we divide it by w, and refer to the ratio as the distortion rate.

The results for the fertilizers distortion are reported in line A3 of Table 1.4 in the column titled marginal, and those of the distortion rate appear in line B3 of that table. The fertilizer variable is an aggregate of different fertilizers. We have only the price of ammonium sulphate, which is more expensive (price per metric ton) than phosphates and potassium fertilizers. For this reason, the distortion rate is biased downward. The ratios are 0.62 for Thailand, 0.91 for the Philippines, and 2.01 for Indonesia (line B3). We return to this discussion below.

Prices based on marginal rates of substitution

We turn now to evaluate the factor shadow prices in terms of other factors, based on the marginal rate of factor substitution. We have already presented the results of the marginal rate of substitution of rainfed land for irrigated land. The marginal rate of substitution of labor for irrigated land is obtained by dividing the marginal productivity of irrigated land by that of labor (line C2 in Table 1.4). The unit of the marginal productivity of labor is output per year of labor worked in agriculture, but not specifically on irrigated land. Another approach is to use the wage rate rather than a marginal value of labor derived from parameter estimates. Calculations based on this approach suggest that labor income equivalent to 1.1 years in Thailand, 4.6 years in Indonesia, and 2.9 years in the Philippines would be required to purchase a hectare of irrigated land (line C3 in Table 1.4).

These values in line C3 are lower than those reported in line C2. This may be related to the fact that the production on irrigated land and rainfed land represents different techniques. Computing the marginal rates of substitution directly requires knowing how inputs used in production are allocated between irrigated and rainfed lands. The data do not reveal this allocation, so additional assumptions are required. We proceed under the assumption that a hectare of irrigated land requires 2.5 as much labor as rainfed land. This ratio is inspired by the ratio of the marginal productivity of the two lands. We illustrate the computation of the labor requirements for irrigated land for the case of Thailand. The total labor input is: $L = L_i + L_r$ where the subscripts i and r signify irrigated and rainfed land. Setting the requirement on a hectare of rainfed land as 1, and that of irrigated land at 2.5, then the ratio of labor on irrigated land to total labor is: $L_i/L = \dfrac{2.5A_i}{2.5A_i + A_r}$ where A_i and A_r represent the area of the two lands. The ratio of averages in Thailand was $A_i / A_r = 0.212$. By substitution, $L_i / L = \dfrac{2.5A_i}{2.5A_i + A_r} = 2.5 / (2.5 + 1/0.212) = 0.346$; that is, about 34.6% of labor in agriculture was allocated to irrigated lands, according to this calculation. Repeating this calculation we get 0.253 and 0.233 for the Philippines and Indonesia respectively. With this assumption, the marginal rate of substitution of adjusted labor for irrigated land is obtained as the ratio of the marginal productivity of irrigated land and that of adjusted labor. The results are 1.6 labor years per hectare for Thailand and the Philippines and 4.9 for Indonesia (line C4). The gap between these values and those in line C3 are by far smaller than the gap between the values in lines C2 and C3. The main impact of this adjustment is for Indonesia. In a textbook competitive economy, the marginal productivity of labor should be the same in all activities and equal the wage rate. In such an economy, the results in lines C2 and C4 would be the same. This is also the case for line C3 if the average labor year in agriculture consisted indeed of 150 working days. The difference between the various estimates indicates that in reality there are several labor markets that are not perfectly connected and hence the difference in the marginal productivity.

The annual shadow rent is capitalized to yield estimates of land values. In this exercise we discount using an interest rate of 0.15. Line D1 presents the capitalized value of the shadow rent of line A1. The results are roughly 2,300, 6,700, and 15,300 1993 US dollars for Thailand, Philippines, and Indonesia respectively. The value for Indonesia is somewhat high by international standards. We can also derive the land value using the marginal rate of substitution of capital for irrigated land, $m(A)/m(K)$. Unlike for the case of labor, we do not differentiate here for allocation of capital between irrigated and rainfed land. Much of the capital is in trees (which are rainfed) and livestock and thus cannot be directly related to irrigated land. This ratio is reported in line C5. To derive estimated land value from these results, we impose the equality $m(A)/m(K) = R/(d+r)$. We extract from this equality the capitalized value of land, R/r, by assuming that $d/r = 1/3$. The results appear in line D2. A comparison of lines D1 and D2 reflects the difference in the discounting rate. For Thailand the values are practically the same because the shadow value of r is nearly .15, which is 3/4 of line A4. The difference for the other two countries reflects the fact that shadow interest rate is lower than 0.15. Still, the country ranking and differences in the order of magnitude are maintained.

How reasonable are these results? In terms of all measures of land values, the estimates for Indonesia are the outlier. Indonesia is an extremely heterogeneous country, and it is impossible to relate the results to any particular situation. What this exercise is doing is taking to an extreme the implications of the information embedded in the aggregate data that we all use in discussions. In order to avoid the big trap of being victims of information that might or might not be relevant, we conducted informal interviews in several locations on several islands, prior to the start of the analysis, in late 1998. The information gathered shows a large spread in land prices, depending on land quality and on the location. The order of magnitude of our results is consistent with this information. Interestingly, the prices were always quoted in terms of rupiah per square meter. Thus, our calculations of prices per hectare perhaps convey a lack of realism. To place the result in perspective, a more meaningful measure would be related to the farm size. For instance, a common rice farm size in Java is 0.2 hectare. Then, the value of a rice farm of this size is reduced to a little over 3000 1993 US dollars. This is high, but this is reality, hence the search for the reasons for these high values goes beyond the quality of the estimates. To sum up, placing such an emphasis on land prices would require gathering more systematic information in the future. This will help to shed light on the role of land in agriculture.

The interviews in Indonesia provide additional information pertinent to our evaluation. First, the results depend on the elasticities, and those should be close to the corresponding factor shares. In crop sharing, the owner gets half of the crop. He has small input responsibility, so on a net basis, the share is slightly less than one half, but well within the neighborhood of our estimates. Second, a daily wage rate often quoted was in the neighborhood of 5,000 rupiah. Year 1998 was a turbulent year, when the average exchange rate was around 10,000 Rupiah per dollar as compared to 2,900 in the previous year. Third, note that in rice farming, contract labor cost for harvest is 1/8 of the crop. If we double this share to include non-harvest activities, we get labor share of 1/4. All these approximations shed some realism to the mechanical derivation of our estimates. As indicated above, the evaluation in terms of dollars might cause a bias. If the Indonesian rupiah were overvalued, as was revealed in later years, then this would cause an upward bias in the derived wage rates and the land value. Also, the results depend on the assumption made on the proportion of the labor reported as agricultural labor actually employed in agriculture.

Changes over time

The time profile of the marginal productivity of the inputs in question is plotted in Figures 1.5-1.9. The differences between countries reflect differences in the elasticities and the average productivity, whereas the time variations reflect only changes in the average productivity because the elasticities are constant over time. There is a distinct growth in the marginal productivity of rainfed land and labor in all countries. This is a reflection of the fact that output grew faster than those inputs. In the case of labor, this was a decision internal to agriculture, in that the labor force was sufficiently large to produce returns below the ongoing wage rates. As indicated in the discussion of labor migration, the gap between the returns in agriculture and the opportunities outside agriculture encouraged migration of labor to non-agriculture.

The trajectory of the returns to land is not the same for the two types of land. In the case of rainfed land, the marginal productivity growth reflects a slow growth of land relative to output. The main expansion was in irrigated land, and that affected the shadow rent on that land. The marginal productivity of irrigated land increased slightly in Thailand, and less so in the Philippines. On the other hand, there was a drastic rise in the marginal productivity of irrigated land in Indonesia. This pattern is a reflection of the fact that irrigated land expanded at roughly the same rate of output growth in the two countries, whereas the expansion in Indonesia lagged behind. This pattern is consistent with the choice of technique model in that capital invested in land was directed to the expansion of the more advance technique, that of irrigated land, or simply in irrigation, rather than in rainfed land. During such a period of transition, the marginal productivity of the restricted resource, irrigation in this case, is constant. Why then has the marginal productivity of irrigated land increased in Indonesia? The explanation is the limited scope for the expansion of irrigated land or on capital.

This is consistent with the very high marginal productivity of capital in Indonesia up until the mid 1970s and the extremely fast growth of the capital stock there, which averaged above 11 percent per year. This rate exceeded by far the growth rate of output, and the marginal productivity of capital kept declining. From the 1980s on, the shadow price of capital reached relatively low levels. This is possibly attributed to the fact that the calculations of the marginal productivity are done with constant elasticity. It is postulated that a different picture would have been obtained if the elasticities were allowed to change with the state variables-- an exercise we could not undertake due to lack of data. Nonetheless, as we discuss in a later section, estimates of the capital elasticity were not sensitive to our choice of sample period. Having said this, it is clear that the economy responded with vigor to the changes in technology. The various government programs, motivated by the desire to increase food supply, supplemented this response by moving resources into agriculture. In the Philippines, the rate of return to capital of agricultural origin fluctuated slightly around 16 percent during the period 1961-1981, and then started to decline gradually to a level of 11 percent. Recall that the rate on machinery was considerably higher, but as this component accounts for only a small fraction of the capital stock, it is not shown here. The situation in Thailand was somewhat different, initially a slow growth rate of capital resulted in an increase in the rate of return from 11 percent in 1970 to almost 24 percent in 1990. This rise in the rate of return triggered a rise in the growth rate of capital, the rate of which averaged 3.15 percent in 1981-1995 as compared to 1 percent in 1971-1981.

The path of distortion in fertilizers is similar in the three countries, but the pace was different (Figure 1.5). The path is indicative of the shortage of fertilizers that was alleviated gradually with time. The appearance of the new fertilizer-intensive crops and varieties generated a considerable excess demand, which resulted in very high shadow prices. With time, the supply increased and the distortion decreased, but remained fairly high in Indonesia and the Philippines. We calculate a distortion rate by taking the ratio of the distortion to the market price. These are reported in Table 1.4 and Figure 1.10. To summarize, in the mid 1990s, the distortion rate was about 0.35 in Thailand, 1 in the Philippines, and 1.5 in Indonesia. We take up this topic again in later sections.

SOURCES OF GROWTH

This section presents the results on the sources of growth. For this we need first to complete the discussion on the approach to the estimation and the role of the state variables. Readers familiar with the approach or interested primarily in the empirical findings can skip this section and go directly to the results.

Specification

The level of output is determined by the implemented technology and the inputs used. In empirical analysis, generally, the technology is represented by a single production function, and this is equivalent to the assumption that the technology is homogeneous. In reality, aggregate output is the sum of outputs produced by more than one technique, and as such the technology is heterogeneous. The presentation of heterogeneous technology in terms of a given production function is problematic. The main reason is that in this case, the set of implemented techniques varies over the sample. The techniques themselves are not observed, and factors' productivity has to be inferred from the available data. The economic problem faced by producers, in the case of heterogeneous technology, involves a decision on what techniques of production to employ in addition to their decision on the level of inputs.

A formal presentation of this approach calls for expressing the optimization problem at the firm level as a choice of the techniques to be implemented (implemented technology) and their level of intensity, given the available technology, product demand, factor supply and constraints, referred to as state variables (Mundlak 1988, 2000). This approach has important implications for the empirical analysis, specifically: (i) the implemented technology is endogenous, and it is determined jointly with the input ratios; (ii) the output path is determined by the evolution of the state variables, and (iii) the aggregate production function is not subject to a concavity constraint, even though each of the techniques is represented by a concave production function.

With a second-degree approximation, the aggregate production function looks like a Cobb-Douglas function, but the coefficients are functions of the state variables and possibly of the inputs:

$$\ln y = \Gamma(s) + \beta(s,x)\ln x + u \qquad \textbf{(1)}$$

where y is the value added per worker, x and s are vectors of inputs and state variables respectively, Γ(s) and β(s, x) are the intercept and the slope of the function respectively, and u is a stochastic term. At each sample point, the data consist of aggregated techniques, the composition of which is likely to change over the sample points. To identify the aggregate production function, it is necessary to loosen the tie between the decisions on the implemented technology from those on the level of inputs. This is achieved when deviations from the first order conditions are more pronounced in the input decisions than in the choice of techniques.

Variations in the state variables affect the production function coefficients directly as well as indirectly, through their effect on inputs. For this reason, estimates obtained under the assumption of constant coefficients provide a distorted view. Often empirical estimates are not robust, as they are sensitive to the choice of sample. This is illustrated by evaluating the elasticity of average labor productivity with respect to a given state variable (say s_i):

$$\partial \ln y / \partial s_i = \partial \Gamma(s) / \partial s_i + \ln x[\partial B(s,x) / \partial s_i] + B(s,x)(\partial \ln x / \partial s_i) \qquad (2)$$

The state variables may not be independent; a change in one state variable may be associated with a change in the others, but this possible relation is ignored here for the sake of simplification. The first two terms show the response of the implemented technology to a change in the state variables, whereas the last term shows the output response to a change in inputs under constant technology. The elasticities in (2) have a time index, which is suppressed here, indicating that they vary over the sample points. The innovation in this formulation lies in the response of the implemented technology to the state variables. To isolate this effect, we rewrite (2), holding x constant to yield the elasticities

$$E_i = \partial\Gamma(s) / \partial s_i + \ln x[\partial B(s) / \partial s_i]. \tag{3}$$

When a production function is estimated under the assumption of constant coefficients, the effect captured by (3) becomes part of the unexplained production function residual. It captures the fact that a change in the state variables may cause a change in the composition of techniques in addition to a change of input used on a given technique. As such it is correlated with the inputs, and as a consequence the estimates are distorted.

Estimation

The estimation of equation (1) requires a specification of the functions Γ (s) and B (s, x) in terms of the arguments, s, and x. The product of B (s, x) with ln x will give quadratic terms. The time series data to be used here are highly intercorrelated (strong multicolinearity), and it is impossible to identify properly the coefficients of the quadratic terms. The approach to the identification is to use the factor shares, but this information is not available. We therefore impose constant slopes, but allow the intercept to depend on the state variables. This reduces the impact of the term in equation (3) on the residual, and thereby removes the bias due to the correlation of the residual and the inputs. To be precise, this eliminates only the linear component of the residual and the inputs, but for linear estimators this is all that matters.

The strong multicolinearity decreases the precision of the OLS estimates. In that case several coefficients are not significantly different from zero, whereas others take on unreasonable values, such as elasticities larger than 1. Elimination of variables with non-significant coefficients is inconsistent with our prior knowledge that the variables belong to the equation. For instance, we do not want to eliminate an important input from the production function. From a formal point of view, the elimination of a variable is equivalent to an imposition of a linear homogeneous constraint on the coefficients of the function. There is a less costly possibility, namely to impose a constraint in such a way as to eliminate a linear combination of the variables in the equation, instead of a particular variable. In general, when a variable, or a linear combination of variables, is eliminated from a regression, the coefficients of the remaining variables are affected, unless the variables are uncorrelated. This suggests that it is desirable to work with orthogonal (uncorrelated) regressors. This can be achieved by constructing orthogonal linear combinations of variables, referred to as principal components (PC).

The analysis begins with the computation of regression in terms of the principal components. The nonsignificant components are eliminated. The coefficients of the principal components are then transformed to coefficients in terms of the original variables. The question is which, and how many, principal components to eliminate from the regression. For this we need a criterion. We follow here the algorithm in Mundlak (1981), which seeks to obtain the tightest confidence region for a given level of significance. We thus eliminated as many principal components as possible, subject to the restriction that the null hypothesis -- that the coefficients are *jointly* equal to the zero -- is not rejected at the 5 percent level of significance. This means that it is impossible to find a linear combination of the eliminated principal components to add to the regression that would, subsequently, have a regression coefficient that is significantly different from zero. The next step is to convert the coefficients of the principal components to those of the original variables.

When the regressors are written as a matrix, the number of regressors constitutes the rank of this matrix. The rank minus the number of eliminated principal components is referred to as the statistical rank. Thus, the statistical rank states the number of linear combinations of the original regressors that exhaust the information embedded in the whole set of regressors. The empirical results show that in most cases, the statistical rank is between 2 and 4. This is a reflection of the high degree of the multicolinearity.

The analysis begins with the estimation of the Cobb-Douglass production function with inputs alone. The inputs are irrigated land, rainfed land, fertilizers, capital and labor. In general, the sum elasticities of a function with inputs alone is larger than one, some elasticities are larger than one, whereas others are negative or not significantly different from zero. This is then followed with a gradual introduction of state variables, the carriers of the implemented technology, starting with public goods consisting of measures of human capital and of physical capital in infrastructure. The next step is to introduce incentives. In the search we inspect the sum input elasticities, the DW statistics, and of course the sign of the coefficients. In the case of Indonesia and Thailand, serial correlation is not a problem. The situation is different for the Philippines, where the data show cyclical variations. To overcome this, we transform the variables as explained in the chapter on the Philippines. The tables include the PC estimates obtained at the 5 percent significance level and in some cases the OLS estimates. The latter are presented just as background information to illustrate how the choice of technique influences the estimates.

In concluding this section, it is important to point out explicitly that we use the primal estimates of the production function to derive the marginal productivities. This is in contrast to the dual approach where the prices are used to identify the production function. There are several reasons why the dual approach is inferior, as discussed in detail in Mundlak (2001). Beyond all this, the basic assumption of the maintenance of the first order competitive condition disguises crucial facts needed to understand the development process in the countries under consideration. This has come out very clearly in our discussion of the empirical results.

State variables

In our application, state variables scale production up or down, while leaving marginal rates of substitution unchanged. The state variables are referred to here as carriers of the implemented technology, because they are correlated with that component of the residual, which reflects the changes in the implemented technology. The state variables included in the final results are roads, representing the physical infrastructure, measures of education and health representing human capital, and measures of incentives. Education is represented by the percentage of agricultural workers who have no schooling for Thailand and Indonesia (referred to as no schooling) and as the mean accumulated school years of the total labor force (schooling) for the Philippines. The infant mortality rates represent the level of health. Both no schooling and mortality declined continuously during the period, whereas road length increased constantly. These variables signify the overall development during the period. We have also tried other measures such as electricity consumption, but the strong multicolinearity prevented their inclusion. These physical and human capital variables can be referred to as policy variables since they are largely publicly financed. Their regression coefficients were significant, and this was not seriously affected by the choice of other regressors (see results in the subsequent chapters). As anticipated in the foregoing discussion, the inclusion of the state variables in the regression affected the estimated elasticities in the expected direction, namely the sum elasticities became close to one and the individual elasticities were mostly positive. As we show below in the discussion of factor growth, the state variables account for an important part of the changes in the total factor productivity (TFP). This is consistent with the assumption that the introduction of the more productive techniques was supported by the improvement in these variables.

Unlike for the policy variables, the role of prices was less consistent, although in general the price coefficients had the right sign. The price effect is pronounced in the Philippines, exists but is not robust in Indonesia, and is not important in Thailand. The price variability was also important in the Philippines. The contribution of prices to growth has several aspects. The regression coefficients of prices represent a direct impact of price variations on output, conditional on inputs. The indirect effect of prices on output is through their impact on the level of inputs and the choice of technology. There is an additional effect, which generally goes unrecognized. When there is a gap between the shadow price of an input and its market price, the employment of the input will eventually rise. This is a generalization of the formulation of the migration equation discussed elsewhere in this volume[11], where the income gap between agriculture and non-agriculture generates flow of labor to non-agriculture. Similarly, for instance, the gap between the marginal productivity of fertilizers and the market price increased the fertilizers supply and consequently the use. This has been the case for all the three countries. There can be various reasons for such a gap, which we will not be discussed here. What is important for our discussion is that as long as the gap prevails, resources will flow, even when the product price declines. This situation blurs the impact of prices on output in empirical analysis.

GROWTH ACCOUNTING

Agricultural technology improved dramatically during the study period. This change in the available technology affected factor prices and their supply, and this in turn resulted in productivity growth. The changes that took place over time are summarized in the growth accounting in Table 1.5. The results are based on the tables in the country chapters. We do not identify here the particular measures used for education or prices in each country, but place them in the same category.

In all countries, the growth rate of output in the first period (up to 1980 or 1981) was fairly similar, about 3.8 percent for Thailand and the Philippines, and 3.4 percent for Indonesia. The rates declined in the second period from 1980 on, and most of the decline occurred in the TFP, not in the total factor. This is true in all the countries, but the magnitude of the decline varied, the steepest decline was in the Philippines, from 0.98 percent in 1961-80 to 0.13 percent in 1980-98. The mildest change was in Indonesia, from 1.58 percent in 1971-81 to 1.49 percent in 1980-98.

[11] See Butzer, Mundlak and Larson (in this volume.)

This seems like a paradox where the technical change is recorded more as a change in total factor rather than in the TFP. This is, however, consistent with changes that take place during the transition to more advanced techniques that are intensive in scarce resources (Mundlak 2000, chapters 6, and 11). It is an indication that the magnitude of the TFP is path dependent, in that it depends on the factors' supply. When the new techniques are intensive in scarce inputs, producers cannot shift immediately to make full use of the new technique because there is an insufficient supply of the critical inputs. As a result, the shadow prices of these inputs rise and this, in turn, raises the level of the total factor, thereby reducing the measured TFP change. This does not reduce the impact of the change in the available technology; it just states that part of the technical change is absorbed in the factor prices. As a consequence the quantity supplied of the scarce inputs increases, and eventually the gap between the shadow price of the inputs and their long run supply price tends to disappear. The situation is different if all the inputs needed for the implementation of the new technique are sold in a competitive market with perfectly elastic supply. In that case, the share of the TFP in the total growth is expected to be more substantive.

Turning to the individual inputs, irrigated land accounts for 10 to 16 percent of output growth. The contribution of rainfed land is substantial in the Philippines and Thailand in the first period, and by far less important in the second period. This pattern also follows from the choice of techniques framework. The new varieties and crops are intensive in irrigated land in contrast to the traditional crops, and consequently the scarce resources are mobilized to the irrigated land and the productivity of the nonirrigated land suffers. For the period as a whole, fertilizers accounted for 14 to 20 percent of the growth. The relative importance of fertilizers was stable in Thailand, declined drastically in Indonesia, and increased in the Philippines in the latter period. The increase in the relative importance in the Philippines is in part a result of the decline in the output growth, so that the same impact of fertilizers carries a high relative weight, and in part an alleviation of the supply condition, as is explained in Chapter 4. The relative importance of capital grew over time in all the three countries, most significantly in Thailand. This is substantive evidence that the new techniques are capital intensive.

There is less uniformity in the contribution of labor to growth. In the first period it was 14 percent in Thailand, 7 percent in Indonesia, and 11 percent in the Philippines. In the latter period a gap is opened up, the contribution almost doubled in the Philippines and Indonesia, and declined to only 2 percent in Thailand. This widening difference in Thailand is consistent with the hypothesis that the initial endowment of rural labor exceeded the needs, and that the output growth was not in the labor-intensive techniques.

The state variables altogether accounted for a large proportion of the TFP growth. They practically exhausted it in Indonesia. There is some variability in each country in the performance between the two periods. The elasticities used in the calculations are the same for the whole period, and it is therefore natural that there will be over and under shooting for shorter sub periods. The overall record, nevertheless, indicates that the state variables serve well as carriers of the implemented technology shocks.

Roads, as a representative of physical infrastructure, accounted for 11-15 percent of output growth in Thailand and Indonesia. This variable was not included in the regression for the Philippines. Schooling had a similar contribution, with some variability over time, as did infant mortality as a measure of health.

The price variable had a substantial contribution; in Indonesia it accounted for 10 percent of output growth in the second period and 5 percent for the period as a whole. In the Philippines, where the prices varied considerably more than in other countries, it contributed about 15 percent in each of the two periods, but with different signs, so the net contribution was nil for the period as a whole. Overall, the contribution of the price spread was negligible.

POLICY IMPLICATIONS

The purpose of the analysis is to understand the undergoing processes, which is a necessary condition for evaluating roles for positive policies. At the level of aggregation of this analysis, we can assess two subjects, growth and income distribution.

The underlying fact is that there were some important changes in the available technology related to agriculture. In addition, there was an important development in non-agriculture in all three countries, at least in part of the study period. The input requirements of the new technologies were skewed, in the direction of capital inputs, mainly irrigated land, fertilizers and other forms of capital. By definition, capital is scarce, and therefore the implementation of the new technologies stretched over a long period of time. This is on the supply side, whereas on the demand side, the countries had to expand their export in order to supplement the growing domestic demand in absorbing the growing supply. The pace of growth was determined largely by the flow of resources to agriculture, and this is reflected in the weights these inputs receive in accounting for the output growth. The message for the future is clear, for the growth to continue, the available technologies must continue to grow. Without such growth, the impact of input growth will eventually decline; we see some evidence to this effect already in the later years of the study period. But this is not the only determinant of future growth. In order to take a full advantage of new techniques, there must be a smooth flow of the required resources into agriculture. Learning from past experience, it would have been much more productive to respond without delay to the jump in fertilizers demand generated by the green revolution by allowing import rather than relying on home production. The grains output forgone due to the anti import bias would have paid nicely for the imported fertilizers.

The state variables indicate that the public goods are important in facilitating the implementation of the new technologies. Physical infrastructure, like roads, integrates areas with major markets and reduces the cost of transactions. Other variables such as electricity, which did not enter the analysis because of the high correlation with roads, have their own important impact. Investment in such projects is not immediately connected with agricultural programs, but nevertheless, has a strong impact on agricultural growth, and of course on the welfare of the rural population. This is also the case with health and schooling. The investment in such programs is constrained by resource availability, and it is in this sense that capital scarcity plays an important role in the determination of the pace of growth.

Assuming that the changes in the available technology facilitate growth, then the focus should be to allow the inputs in demand to flow into agriculture and to avoid a gap between their shadow price and the long-run supply price. This has several consequences: growth will be fastest, and the benefits will be directed mainly to the farmers rather than to the distribution channels that always benefit from shortages. Not independently, the contribution of TFP will increase relative to total factor. The statement on the removal of obstacles to the flow of resources is meant here to be a road signal and not a detailed road map of an elaborate program. The elimination of obstacles has many aspects related to the distribution system, bureaucratic standards, and elimination of monopolistic lacunas along the way. It may not sound like a dramatic program, but its importance cannot be exaggerated.

The new technologies are on the whole labor-saving, and this, together with the natural population growth in agriculture, generates an oversupply of labor in agriculture. The excess supply is directed to non-agriculture, but the ability of non-agriculture to absorb labor has to develop at a rather fast rate. The reason is that the more productive techniques in many industries are laborsaving and are more profitable even in countries with low wages. Low agricultural wages is one outcome of this gap. That having been said, as we show in a companion paper in this volume, the same type of investments in education and health services that spur productivity gains on the farm also facilitate the flow of agricultural labor resources to other sectors[12].

Some of the country papers suggest that the alleviation of rural poverty was not progressing well, or did not exist at all. This can be thought of as inadequate transfer policies, but the more fundamental question is why poverty was not disappearing in light of the growth that was taking place. This issue is another aspect of the nature of the new technologies discussed above. Because the technologies are labor saving and the wages are kept relatively low, labor income is low. The wage rate did improve in some countries, but the big unknown is the average number of on-farm employment to which the daily wage rate is applied. In this situation, the welfare of landless labor is not improving, or may even be deteriorating. On the other hand, the situation of land and capital owners is improving because the demand for the resources in their possession increases and with it their returns. Over and above this effect, the land owners have a natural advantage of being able to work more days on the farm and thereby increase their annual wage income even when they would be attributed the same daily wage rate. Aside from transfer programs done for humanitarian purposes, the alleviation of rural poverty depends largely on the development of employment opportunities outside agriculture. This can still be in the rural areas, but this is a separate issue related to the geography of development.

The terms of trade of agriculture play several roles, some of which are backstage. The flow of resources into agriculture depends on the relative profitability in agriculture, and this in turn depends on the real product price. Similarly, the choice of new techniques is sometimes justified only in a good price environment, which helps to offset initial setup cost, as well as risk. The real price is determined by the input prices and also by the prices of nonagricultural products. Such prices are determined in the economy at large, which generates the economic environment within which agriculture operates. Even though the macro environment is not part of agricultural policy, it can still hurt

[12] ibid

agriculture. Finally, world agricultural prices affect the domestic prices and thereby the profitability of agriculture. The challenge here is for the countries to form the economic environment that will allow the countries to match the progress made in the rest of the world which has led to the declining prices.

2. Agricultural productivity - Thailand

BACKGROUND

The short summary of events is based on Shin'ichi Shigetomi (this volume), Ammar (1996), and Coxhead and Plangprphan (1998), among others.

Agriculture

Thailand experienced agricultural-led growth at a fast rate from the 1950s through the 1970s, and at a slower rate thereafter. In the process, the share of agriculture in GDP declined from around 38 percent in 1951 to around 10 percent in 1995. Over the same time period, manufacturing rose from 13 percent to 32 percent. The pace of growth of agricultural production outpaced that of demand. This expansion facilitated growing domestic supply of food at relatively low prices and growing export of agricultural products. The export served as an important source of foreign exchange. In addition, agriculture contributed the labor needed to develop the nonagricultural sector.

Agricultural employment increased in the 1970s and the 1980s until it started to decline in 1989. Its share in the labor force, however, has declined all along, and this was accompanied by growing migration from agriculture to the cities. The share of the total active population in agriculture was 83 percent in 1961 and declined to 57 percent in 1999. The economic boom caused a rise in wages in agriculture and in non-agriculture.

Agricultural policy underwent some major changes over the years. Until the mid 1970s agriculture was taxed. This policy was changed in the mid 1970s to income and price support, and agribusiness promotion. Starting in the early 1980s, policies shifted to agricultural protection, production diversification and control.

The economy

Prior to the 1960s Thai agriculture relied largely on rice and rubber production. The 1960s and the 1970s was a period of high economic growth. The modern rice varieties were introduced in the late 1960s and their relative importance started to gain impetus in the 1970s. Agriculture benefited from the growth of the economy and from the favorable world prices for agricultural products in the 1970s. Export expanded, and so did cultivated land. This was associated with crop diversification, including the expansion of the production of export-oriented upland crops. The share of export in total agricultural output was 31 percent in 1971; it went up to 58 percent in 1982 and thereafter fluctuated around 50 percent. The early 1980s were painful for the economy as a whole, including a recession that lasted through 1986. This was then followed by a period of industrial boom and an acceleration of economic growth that culminated with the economic crisis of 1997.

Demand

Per capita rice consumption started to decline in 1971-75 from a level of about 145 kg to about 105 kg in 1995-97. Output increased at a faster rate than consumption, and the surplus started to grow from roughly 2 million MT in 1961-75 to 6 million MT in 1996-97. In view of the impressive growth of export, it is tempting to assert that the demand is not a constraint to agricultural production (Martin and Warr, 1993; Punyasavatust and Coxhead, 2001). This assertion ignores the fact that global demand is a constraint to global agricultural output, and when supply growth exceeds demand growth, prices decline; this has been the case in the last several decades. In fact, for some time Thailand tried to use its marketing power and control export through export taxes in order to prevent world prices from falling. Still, falling prices do not preclude countries from exploiting their comparative advantage, exporting some products, thereby alleviating the constraint of domestic demand. Even then, output growth in most cases does not deviate much from the growth in demand. This we can see by estimating a pseudo - Engel curve by regressing per capita agricultural output on per capita total output. The values for the resulting elasticity are 0.3 for 1961-95; 0.26 for 1971-1995; 0.51 for 1961-1971; 0.28 for 1971-1981; and 0.25 for 1981-1995. This elasticity expresses the proportional growth in per capita agricultural output associated with a proportional growth in per capita total output. As output here is GDP, it is a good proxy for income. These values are not unreasonable.

As indicated by Honma and Hagino (this volume), Thailand's export growth rate for agricultural products averaged 9.7 percent per year for the period 1961-63 to 1995-97. The growth rate during the commodity boom of the 1970s was particularly impressive, 20 percent per year in US dollars and 10 percent per year in volume. Thailand maintained the export expansion until the currency crisis in 1997. The main export crops are rice, rubber, cassava, sugar, and maize. The export of maize and cassava were important in the 1970s, but disappeared later on when the targeting quota of Japan and the EC were terminated. This suggests that such export was not a pure manifestation of comparative advantage and that the implicit social price received was not identical with the actual price. The level of export was sustained by expansion of natural rubber and sugar exports.

DATA PATTERNS

The variables and their labels and growth rates are presented in Table 2.1.[13] Figure 2.1 displays a graphical summary of output and inputs for the sample period of 1971-1995. The output and all the inputs show a positive trend for the whole period, but with some variability in the pattern. Labor reaches a peak in 1989 and starts declining thereafter, and rainfed land reaches a plateau in the mid 1980s. Negative trend is observed in infant mortality, in no schooling, and in the real exchange rate. This is reflected in the strong correlation between the trended variables as can be seen in the correlation matrix (Table 2.A).

To get a better view of the time pattern of growth, we compare the growth rates of the variables in the 1970s with those from 1981-1995. The growth rate of output declined, between these two periods, from 3.8 to 3.2 percent per year, and that of irrigated land declined similarly from 3.8 to 2.6 percent. Rainfed land grew only in the first period, at an average rate of 1.36 percent and was practically stable in the second period. Thus, the extent of total land expansion is equal to that of irrigated land.

[13] We used natural logarithms except for variables noted with a star. The rates of growth are obtained from a trend regression. For the starred variables, the values are the trend coefficients in terms of the original units (percentage points).

Fertilizers displayed the most striking growth, in the neighborhood of 10 percent, and that changed only slightly over time. On the other hand, there was a drastic increase in the growth rate of capital, from 1 percent to 3.1 percent and a decline in the growth rate of employment from 3.75 percent to 0.42, indicating a capital labor substitution.

As to the market variables, we examine two price measures, real farm price, obtained by deflating the farm price by the consumer price index, and p, the ratio of agriculture to total *GDP* deflators. Both measures show a rise in the 1970s, the period of commodity boom, and a decline in the second period. Also, the prices were more stable (at their lower level) in the second period as indicated by the spread of p.[14] The decline in the real exchange rate began already in the first period, and this was flagging the subsequent deterioration in the internal terms of trade of agriculture.[15]

Because of the strong correlation between the variables, the number of linear combinations of the variables (principal components) needed to exhaust the information embedded in the regressors is rather small. Generally two components exhaust about 98 percent of the total variance of these variables. We have only 25 observations, and this forces us to reduce the number of the contemplated regressors. The results of the analysis are described below.

ESTIMATION

The reader who is interested only in the final results is invited to skip the current discussion and to move directly to Tables 2.4-2.5. The purpose of the discussion leading to Table 2.4 is to explain the considerations leading to the final results. The main issues are the choice of the PC estimator to overcome the strong multicolinearity, the role of the public inputs as carriers of the technology, and the role of prices.

We begin the estimation of the Cobb-Douglass production function with inputs alone. This is then followed with a gradual introduction of state variables, starting with public capital (human and physical), followed by the incentives. In the search we inspect the sum input elasticities, the DW statistics, and of course the sign of the coefficients.

Table 2.2 presents a production function with inputs only. The statistical rank of the PC estimation is 2, reflecting the high correlation among the inputs. The sum-elasticities is high, 1.47 and 1.68 for the OLS and PC estimates respectively. This is interpreted as a reflection of the fact that the rise in inputs confounds the technical change and other state variables. The last column contains the normalized PC elasticities, obtained as the ratio of the individual elasticities to the their sum. As we will see below, these values are close to the final results of the analysis. In what follows, we present only the PC results.

Table 2.3: The next move is to introduce the infrastructure variables, or public goods. Because this group is highly intercorrelated, the size of the group was reduced. For schooling we use the measure of no schooling because it displays more variability around the trend line than the average level of schooling. The degree of infant mortality

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[14] The spread was calculated as a moving standard deviation of the price ratio from the three previous periods.

[15] The real exchange rate was calculated as the nominal exchange rate deflated by the consumer price index. It ignores the foreign inflation and as such it is biased downward.

is chosen to represent the level of health, and road length represents physical infrastructure.

The introduction of these three state variables did not change the statistical rank, and two principal components still summarize all the information contained in the regressors. The allocation of the explanation, however, is different, and the sum elasticities is now close to 1. This is consistent with the assumption that the level of public inputs is correlated with the changes in the implemented technology. The last column presents the normalized elasticities.

Table 2.4: In this table we present the results with two price measures added to the regression: the real farm price of rice and the inflation rate.[16] The statistical rank is still 2, even though the prices are not highly correlated with the other regressors. The signs of the respective coefficients are in line with conventional expectation, even though this expectation stands on a weaker ground within the choice of techniques framework. The impact of the introduction of the incentives on the input elasticities is rather weak, but sufficient to reduce the sum elasticities to .91. The weak influence may reflect the fact that the variability in the incentives is rather low compared to the big trend changes in the other regressors and the output. This low marginal contribution of the incentives occurs also in other combinations of the incentives listed in Table 2.1. This outcome is a major difference from the results obtained for the Philippines where the price variability was larger and the trend of the regressors was weaker.

The normalized elasticities of this regression are presented in the last column. There is a great deal of resemblance in the order of magnitudes of the normalized elasticities in the three tables. As indicated above, this is interpreted that the state variables are strongly correlated with the technology carriers. This is not a claim that the public inputs included are identical with the technology variables. It simply indicates that due to the strong correlation of the public inputs with the changes in the implemented technology, a subset of these variables can represent the disturbances that caused the sum elasticities in the naked regression to exceed 1.

In the discussion that follows, we concentrate on the normalized elasticities in Table 2.4. The sum elasticities of the irrigated and rainfed land is .38. It is convenient to identify in the discussion the estimated elasticities with factor shares. In that case, we can say that land accounted for about 38 percent of output. The share of rainfed land is about twice that of the irrigated land. We come back to this result below.

The fertilizer elasticity is .06, which is in line with the value obtained, and discussed, for the two other countries, and in other studies of Thailand (e.g. Mundlak 1993). To judge the reasonableness of this value we note that the proportion of fertilizers and lime in total farm household income in Thailand in selected years was: 2 percent in 1963, 5 percent in 1970, 1977 and 1981, 4 percent in 1971, and 6 percent in 1983 (Mundlak, 1993; the source is Agricultural Statistics of Thailand and Statistical Yearbook of Thailand, various years). The elasticity of capital is 0.41, which is quite high, and that of labor is 0.14, which is quite low. These values are consistent with the hypothesis that the new techniques are capital intensive and that capital was scarce.

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[16] The consumer price index was used in the calculation of these variables.

SHADOW PRICES

The discussion follows the evaluation in Chapter 1, and we go directly to the results in Table 2.5 and figures 1.5-1.9. The ratio of the marginal productivity of irrigated land was roughly 2.5 times that of dry land. This ratio declines from 3.5 at the beginning of the period to 2.2 at the end of the period. The decline reflects an increase in the productivity of rainfed land, probably as a result of the introduction of new crops and overall practices. On the other hand, the expansion of irrigated land might have caused a decline in its productivity on the margin because the new land brought under irrigation may be of lower quality compared to the prevailing irrigated land. Similarly, the expansion due to the increase in irrigated land may lead to lower value crops. The productivity differential of the two lands is similar to that in the Philippines, but much smaller than that obtained for Indonesia.

There is a considerable discrepancy between the estimated labor elasticity and the labor share. This discrepancy points at a profound data problem. The labor share was computed by multiplying the daily wage by the labor data, under the assumption of 150 working days per year. The results are presented in Figure 2.2. The agricultural labor share, calculated in current prices, fluctuated between 0.4 and 0.7, and its average was 0.58. This is roughly 4 times the estimated labor elasticity. But what is more striking is the low value of the labor share in non-agriculture (Figure 2.3), which declined from a level of 0.16 in the early 1960s to a level of 0.06 in the late 1980s, with an average of 0.098. It is very likely that the sectoral composition of the labor data exaggerates the labor in agriculture and understates the number in non-agriculture. For non-agriculture, we could double the working days per year, which would then give a little more realistic labor share. We have, however, no information basis to change the data, and will therefore continue with the discussion based on our estimates keeping in mind the data limitation.

The ratio of the marginal productivity of irrigated land to labor declined from nearly 1.74 labor years in 1971-1981 to 1.44 in 1981-1995 (line C.4). This decline may reflect a decrease in the productivity of irrigated land or the rise of labor productivity. The average for the whole period is 1.55 years. Capitalizing this by a discount rate of 0.15, it would have required nearly 10 years of work to acquire a hectare of irrigated land. The value was higher in the 1970s and declined in the later period. Multiplying this value by the annual wage of \$311 (in 1993 dollars), the derived value of a hectare of irrigated land varied from \$3,306 in the first period to \$3,145 in the latter period, with an average of \$3,214 for the whole period (these values are not reported in the table). Taking an alternative approach, the value of irrigated land is also derived by discounting the marginal value product of land by 15%. These values are reported in line D.1 and are lower than the wage-based values.

The marginal productivity of irrigated land in terms of capital varied between \$2,095 per hectare in the first period to \$1,599 in the latter period (line C.5). This is the ratio of rent to the user cost of capital. Assuming that the depreciation rate accounts for 1/3 of the interest rate, we obtain capitalized value of land that varied in the two periods from \$2,787 to \$2,127 (line D.2).

The ratio of the marginal productivity of labor to capital is about \$400 for the whole period. This is the estimate of the ratio of the wage to the user cost of capital. The agricultural wage rate was \$311. From this we solve for the user cost of capital. The outcome is 78 percent for the whole period with small variations over time. This is quite high. This is a result of either high marginal productivity of capital or, more likely, a low marginal productivity of labor. This in turn may be related to the ambiguity in what the labor data contain. We have alluded to this above. To evaluate the impact of this, assume, for instance, that the reported labor force in agriculture is twice as high as the actual force. A correction for this would reduce the labor capital ratio and therefore double the shadow price of labor, and reduce the shadow interest rate, without changing the elasticities. A reduction of the elasticity of capital compensated by the elasticity of labor would also reduce the shadow interest rate. Such calculations highlight the fact that our conclusions are sensitive to the assumption with respect to the labor force.

GROWTH ACCOUNTING

Table 1.5 presents calculations of the TFP for the period as a whole and for the two sub periods, 1971-81 and 1981-1995. For the whole period, output grew at an average rate of 3.35 percent, of which 67.6 percent is due to the growth in total factor and the remaining 32.4 percent is due to TFP. In the earlier period 1971-1981, output grew at an average rate of 3.8 percent and the division to TF and TFP is similar to that of the whole period. In the later period, output growth rate was 3.2 percent, of which 73 percent is attributed to total factor and only 27 percent to TFP. In other words, the growth rate of TFP declined from 1.27 percent in the first period to 0.87 percent in the second period, a decline of nearly 50 percent. At the same time, total factor growth changed only slightly. This movement is consistent with changes that take place during the transition to more advanced techniques that are intensive in scarce resources. Referring to Table 2.1, it is seen that the growth rate of capital was 3.15 percent in the second period as compared to 1.0 percent in the first period. Also, the growth rate of fertilizers was quite high in the two periods.

In terms of the contribution of individual inputs to growth, labor contributed 14.3 percent in the first period and only 1.9 percent in the later period, and for the period as a whole it amounted to 8.6 percent. This is a rather small contribution, which is consistent with the fact that the initial endowment of rural labor exceeded the needs, and that the output growth was not in the labor-intensive techniques. Fertilizers accounted for 19 percent of the growth, which is indeed substantial. It is, however, an alarming finding because this source of growth cannot go on forever. The contribution of irrigated land declined from 13.3 percent in the early period to 10.7 percent in the subsequent period. At the same time the contribution of rainfed land declined from 8.9 percent to mere 0.7 percent. This means that practically the total land expansion was equal to the expansion in irrigated land. Finally, the contribution of capital is substantive and increased drastically from 11 percent to 40.6 percent respectively.

Turning to the state variables, they account for 37.5 percent of the growth in output for the whole period, as compared to TFP of 32.4 percent. This indicates that, for the period as a whole, the weight given to the state variables exaggerated slightly their importance as carriers of the implemented technology. For the sub periods the situation is reversed. The elasticities used in the calculations are the same for the whole period, and it is therefore natural that there will be over and under shooting for shorter sub periods. Most of the contribution of the state variables is due to roads (a proxy for physical infrastructure), education (a decline in the percentage of agricultural workers with no schooling), and in health (a decline of infant mortality rates). To support the statement that the variable roads is a representative of the group of physical infrastructure we reran the regression in Table 2.4 with electricity added. The various coefficients changed very little except for roads that declined to .08 and that of electricity was .045. As shown in Table 2.1, the growth rate of electricity was about twice that of roads, hence their contribution to growth was nearly the same.

DISCUSSION

In the literature one can find claims that agricultural production in Thailand increased largely due to land expansion. This might have been the case in the earlier years. This, however, is not the case in the study period during which land expanded at the average annual rate of 1.1 percent, whereas the other inputs expanded at higher rates. Specifically, fertilizers increased at an average annual rate of 10 percent, whereas irrigated land and capital increased at an average annual rate 3.5 and 1.8 percent per year respectively. Consequently, total factor accounts for 67.6 percent of the growth in output. Subtracting from this the contribution of rainfed land, 4.5 percent, we obtain that the contribution of total factor, less rainfed land, to growth accounted for 62 percent of the growth. This is not much different from the experience of other Asian countries. This is consistent with the proposition that in general shocks that improve profitability cause land expansion and a positive change in the intensive margins, (Mundlak 2000). It appears that Thailand is no exception. The rise in TFP reflects improved varieties of crops and changes in output composition. The growth of output was also influenced by the growth of livestock production, which automatically increased the output per hectare.

The growth of agricultural production was associated with a remarkable growth in the public goods: roads, electricity, health, and education. All of these have been essential for the implementation of the improvements in the available technology that was taking place in Thailand as well as in other Asian countries.

Finally, the incentives did not play an important role in the estimated production function. This indicates that the growth conditions were generally favorable and were not seriously damaged by the declining prices during the period. Note, however, that the analysis does not cover the macro shocks associated with the financial crisis in the later years.

3. Agricultural productivity - Indonesia

DATA PATTERNS

The chapter by Kawagoe provides a broad historical perspective for the agricultural development in Indonesia. We begin here with a review of the changes in the variables pertinent to our analysis. Figure 3.1 displays a graphical summary of the output and inputs variables, and the growth rates of the pertinent variables are presented in Table 3.1.[17] A distinct positive trend is observed for the whole period in output, labor, and the public inputs. Fertilizers and capital show a slow start, which later on gains momentum: fertilizers in the early 1970s, and capital in the early 1980s. A different pattern is observed for agricultural land and irrigated land. Land shows a slight decline over the period 1961-1984, before commencing a rise. Irrigated land was flat until 1975, and starts its climbing thereafter. This behavior of land is in contrast to the trend observed in output and the other inputs over the same period and as such raises suspicion.[18] The data source for land is FAO, and we have no judgment on its accuracy. The coverage of country sources for data on irrigated land begins in 1978, and from then on its pattern is close to that of the FAO. Being in doubt, and in view of the importance of land, we have decided to ignore some of the earlier observations and concentrate on two sub periods: 1971-1998 and 1980-1998.

The situation of the price measures is not any easier. We examined several measures. The ratio of the GDP deflator of agriculture (excluding forest and fishery products) to that of total GDP covers the whole period of 1961-1998. This measure shows an overall negative trend. Other price measures such as the ratio of wholesale prices of agriculture to the total, or the ratio of agriculture to manufacturing show a positive trend. These two price series start in 1971. The fact that different measures show opposite patterns suggests a difference in coverage. It is possible that the wholesale prices include taxes and subsidies and as such reflect the internal terms of trade, whereas the GDP deflators are indicative of external terms of trade. We report here results with the wholesale price ratio. In addition to the level of the price ratio, we also examine the impact of its spread, as a measure of sectoral price risk. For a measure of overall price risk we look at inflation. There was a strong inflation around 1965, but this period is not part of the current analysis.

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[17] We used natural logarithms except when noted with a star. The rates of growth are obtained from a trend regression. For the starred variables, the values are the trend coefficients in terms of the original units (percentage points).

[18] Kawagoe (this volume, p.32 of draft cs3) writes that "[t]he new Indonesian government, which placed an emphasis on the rehabilitation of irrigation in the development policies in the 1950s and the 60s. Under the New Order, the government also emphasized irrigation. In First Five-Year Plan (*Repelita I*) of 1969 to 1973, high priority was placed on the improvement of the infrastructure in order to increase food production. Nearly comparable amount of industry, Rp.236 billion, or 17 percent of the budget of the plan, was assigned to the rehabilitation of irrigation. Another Rp.50 billion was spent for the rice intensification program at village level (Palmer 1978 p.20)." It might well be that the efforts did not bear immediate results, or else the data do not reflect these developments.

Table 3.1 compares the growth rates of the variables by sub periods. The growth rate of output declined somewhat from 3.39 percent in 1961-80 to 3.04 percent in 1980-98. The more drastic change in growth rates is observed in fertilizers, which declined from 12.45 in the first period to 3.69 percent in the later period. Capital showed a very strong growth throughout the whole period, but its initial level was relatively low. This reflects the low level of investment in agriculture as shown in figure 3.2. During 1970-1985 the share of investment in agricultural GDP fluctuated below 5 percent. Investment started to climb in 1984, where it stood at a 1 percent level to 18 percent in 1990. It fluctuated thereafter, but stayed at higher levels. The growth rate of labor fluctuated in the range of 1 to 2 percent. Land and irrigated land grew mainly in the second period, reflecting the data puzzle alluded to above. The pattern of price changes depends on the measure, real wholesale price increased and real price deflator declined. The public goods grew constantly.

The strong trend in the variables is reflected in the correlation between the variables as can be seen in the correlation matrix in Table 3-A. Because of this correlation, the number of linear combination of the variables (principal components) needed to exhaust the information embedded in the regressors is rather small. Generally two components account for more than 95 percent of the total variance of the regressors. In order to allocate the variability of output to the five inputs we use the principal components estimator. Even so, we do not use all the variables that might have affected output. Because of doubts with respect to the land data, we end up with the sample period of 1971-98. We thus have only 28 observations and this forces us to settle down with a subset of all the contemplated variables. The results of the analysis are described below.

ESTIMATION

The reader who is interested only in the final results is invited to skip the current discussion and to move directly to Tables 3.5-3.7. The purpose of the discussion leading to Table 3.5 is to explain the considerations leading to the final results. The main issues are the choice of the PC estimator to overcome the strong multicolinearity, the role of the public inputs as carriers of the technology, and the role of prices. In view of the above remarks on the land data, we have analyzed the data for three periods, 1961-1998, 1971-1998, and 1980-1998, but to avoid long technical discussions we restrict the discussion to the latter two periods.

We begin the estimation of the Cobb-Douglass production function with inputs alone. Next, we introduce public capital (human and physical), and this is followed by the incentives. In the search we inspect the sum input elasticities, the DW statistics, and of course the sign of the coefficients. The tables contain the PC estimates obtained at the 5 percent significance level. Table 3.2 presents also the OLS estimates, as a background, to illustrate the impact of the strong multicolinearity. In general, the DW statistics do not flag serial correlation. The R2 is high in all cases, but this does not mean much in view of the strong trend in the variables.

Table 3.2: The table presents a production function with inputs alone. The statistical rank is 3 for the whole period and 4 for the shorter period. The order of magnitude of the estimates is not sensible, and the sum-elasticities for the shorter period

is excessively high. This is interpreted as a reflection of the fact that the rise in inputs confounds the technical change and other state variables.

Table 3.3: The next step is the introduction of the infrastructure variables, or public goods. From here on we present only the PC estimates. The initial set of public goods consists of no schooling, infant mortality, and length of roads. We prefer the use of no schooling because it displays more variability around the trend line than the average level of schooling. The degree of infant mortality is chosen to represent the level of health, and road length represents physical infrastructure. The introduction of these three variables to the initial set of Table 3.2 reduced the statistical rank to 2. That means that two principal components summarize all the information contained in the regressors. The estimates, however, are quite different from those in Table 3.2, and the sum elasticities is now close to 1. This is consistent with the assumption that the level of public inputs is correlated with the changes in the implemented technology. The last column in each block presents the elasticities that are normalized so that they sum to 1.

Table 3.4: In this table we present the results with two price measures added to the regression: the real price of agriculture lagged one year, taken as the wholesale price ratio, and its spread. The main impact of the introduction of prices is to change the statistical rank to 4 for the longer period and to 1 for the shorter one. There is some similarity, however, in the order of magnitude of the estimates for the two periods. Comparing to Table 3.3, the change in the coefficients caused by the price variables is not substantial. There are two possible explanations for this relatively weak effect of the price variables: First, the price does not matter at all. This is not supported by the data because, as shown in Table 3A, the correlation between output and the wholesale price measure is 0.73. Second, Table 3A shows that the inputs are also correlated with the price. It is therefore likely that much of the contribution of prices is channeled through the inputs, and it is the *net* direct effect of the price that is weak.

The main outstanding result in Tables 3.3 and 3.4 is the very high elasticity for land, particularly irrigated land. The sum elasticities of irrigated and rainfed land is 0.7, meaning that the two categories of land account for roughly 70 percent of output. A possible explanation for this result is that common shocks affect output and irrigated land. To test this hypothesis, and overcome its consequences, we estimate the average irrigated land productivity function where output and inputs are expressed as ratios to irrigated land. In this equation output and inputs (in logarithms) are expressed as differences from irrigated land, and thus the common shocks are likely to disappear. The results are presented in Table 3.5.

The table presents two regressions, without and with prices. The estimates in the 'irrigated land' row are the values needed to bring the sum input elasticities to one. In both regressions the sum land elasticities is roughly 0.5. This reduction is consistent with the above hypothesis. The reduction in the land elasticities is compensated by the increase in the labor elasticity. The correlation coefficient of labor with irrigated land and with capital is high (Table 3A), and this may cause the variability in the estimates. Another striking difference from the results for the other two countries is the low capital elasticity. The fertilizer elasticity is .05, which is in line with the value obtained, and discussed for the Philippines and for Thailand. The sign of the price elasticity is positive and that of the price-spread is negative.

SHADOW PRICES

The magnitude of the new opportunities of the green revolution in Indonesia is illustrated by the change in yield of paddy from 1.76 MT per hectare in 1965 to about 4.5 MT per hectare in 1996 (Kawagoe, Figure 5.1). This change is reflected in the rise in the marginal productivity of irrigated land, as well of other factors. The changes are summarized in Figures 1.5 to 1.9 and in Table 3.6. There was a continuous dramatic increase in the marginal productivity of irrigated land, measured in 1993 dollars per hectare, from a level of $1,200 in 1961 to a level of nearly $3,000 at the end of the 1990s. The level is high relative to the other countries, but not less impressive is the fact that the growth continued relentlessly at a high pace.

The new technology was intensive in fertilizers, and its introduction generated a big jump in demand for fertilizers. Instead of importing the fertilizers to meet this new demand, Indonesia relied on home production, which was far from adequate. As shown by Kawagoe (Table 5.2), fertilizers production was starting to gain momentum in the late 1970s, but it was not until around 1985 that production reached one half of its 1995 level.[19] Consequently, excess demand was formed which is reflected in a gap between the marginal productivity of fertilizers and its official price used in the national accounts in the computation of value added. This was reflected in actual domestic prices, and consequently fertilizers had to be heavily subsidized (Kawagoe, Figure 5.5). As seen in Figure 1.5 the gap, or the distortion, measured in 1993 dollars per metric ton, was very high in the early 1960s, the beginning of the green revolution, and was even rising to a peak exceeding $9,000 in 1965. From then on it started to decline to a level of $1,000 from the mid 1980s. The distortion rate declined from a value of 4 in 1971 to about 1.5 in 1998. It can only be expected that under such a situation there would be opportunities to gain from trade of privileges granted under various government programs. There is no question that the reliance on home production of fertilizers to meet the new demand was very costly in terms of agricultural output and farmers income.

The marginal productivity of rainfed land also increased over the same period by a factor of 3, but its level was only around 6-7 percent of that of irrigated land. This rise is due to the improvement and expansion of non-rice food crops and export crops as described by Kawagoe.

The new technology has been capital intensive, at the farm level as well as in terms of infrastructure requirements. Indeed, we detected the importance of the infrastructure, physical and human, in our estimates of the production function. Initially, the capital level was low, and as indicated above, the rate of return was very high. It was only as late as 1985 that the ratio of investment to agricultural output started to rise above the 5 percent level. The rise in this share can be seen as a response to the high rate of return. This rise in investment led to a subsequent decline in the rate of return and an increase in the rent of land. Public programs such as BIMAS financed some of the capital flowing to agriculture. Whether it was done knowingly or not, the same forces that determined the high shadow interest rate might have affected these programs. In any case, the flow was rationed and also costly to obtain. Plantations also benefited some of

[19] Other countries followed the policy of reliance on domestic production also. McGuirk and Mundlak (1991) discuss the issue for the case of India.

the time from subsidized credit. Thus, in reality some investments were made at subsidized credit, and this may bias downward our calculation of the shadow rate of return.

The changes in technology are well reflected in the shadow prices of land. Those are obtained by capitalizing the shadow rent, as plotted in Figures 1.6 and 1.9, by a discounting factor of 15 percent. Using 1993 dollars, the value of rainfed land increased from roughly $440 per hectare in 1961 to over $1,300 in 1998. At the same time, the shadow price of irrigated land increased from $7,800 to nearly $20,000 per hectare.

GROWTH ACCOUNTING

The growth accounting presented in Table 1.5 above showed that factor accumulation accounted for 56 percent of the total growth in the period 1971-1998, leaving 44 percent for changes in the total factor productivity. Because the various alternative regressions differed in the estimated elasticities, it is desirable to check how sensitive is the growth accounting to the choice of regression. Table 3.7 presents calculations for two alternative elasticities taken from Tables 3.4 and 3.5. The main difference between them is the order of magnitude of land and labor elasticities. The results are fairly similar, factor accumulation accounts for 59 and 55 percent of the total output growth. The contribution of the state variables practically exhausts the TFP growth, and this supports the conclusion that the state variables serve well as carriers of the technology shocks. The relative contribution to output was about 12-13 percent each for the three public goods: schooling, roads and health, and 5 percent for prices. The contribution of the price spread was negligible.

DISCUSSION

Indonesian agriculture consists of many smallholders on the one side and big plantations on the other side. The backbone of the small farms is rice farming, but there are smallholders of tree crops as well. On the whole, the rice farms are small in size and do not provide full employment to the family. This forces the families to seek off farm work. The ease of such opportunities varies geographically. It is relatively easy in Bali, a small island with a developed tourist industry. In fact, there were complaints that tourism competes with agriculture. But in other areas, the apparent limited on-farm employment as well as non-farm opportunities result in a relatively low wages. Rural poverty is of concern, and this influenced policies aimed at the improvement of the profitability of rice production. However, since rice provides only a fraction of the family income, this measure by itself cannot be an efficient way to overcome rural poverty. In the long run, if and when labor demand from nonagriculture will expand, labor will leave agriculture. When farmers are asked what are their career priorities for their children, the universal answer was non-agriculture if possible. This is revealed by the pervasive fast growth of schooling.

The fact is that farmers are poor. Is that an indication of the welfare of agriculture? The answer is no if we look at land prices. The ratio of land price to the wage rate is very high by international standards. This can be easily seen by dividing the price of land by the wage rate in other countries, and specifically in the big grain exporter countries. This is also reflected in the factor share of land in the contractual arrangements, 50 percent of the rice in crop sharing. In part, the profitability of agriculture is due to the low labor cost. For this reason, we can think of the labor cost of land as a good indicator of the future evolution of the sector. It will decline when other employment alternatives develop and wages rise.

The question still looms, why then are the land prices so high? And not independently, why are farmers willing to tie their capital to land? Again, the answer is lack of alternatives. Suppose the farmer sells his 0.2 ha of land, what can he do with the money? Move to the city and seek shelter and work, with all the risk involved? There is a better strategy, family members move to non-farm work while keeping the family roots in the village. Eventually, the family may sell out, but this is after establishing its roots in the city. This is the reason why only a small fraction of the labor force leaves agriculture in any given year, which is a universal finding. Farming provides shelter and village community, and this is the true realization of the phrase "Farming is a way of life". This attribute is built into land prices, and it is applicable more to established farms than to frontier land and to land for tree plants such as palm, coffee, cacao, and rubber. In the case of frontier land, labor is a scarce factor and the pace of the development is determined by the supply of labor. This implies a shadow price of labor higher than the wage rate in labor scarce areas, and consequently lower land prices. Also, the land price is strongly affected by the proximity to roads and, of course, to cities. This reflects lower transportation cost, but more so, proximity to employment opportunities.

NON-RICE AGRICULTURE

The sector of tree crops has expanded rapidly, due to favorable profitability. It responded favorably to changes in the real exchange rate, which generated a boom in those products that are priced by the world market, such as cacao and palm oil. The sector consists of smallholders as well as of big plantations run by corporations; some of them are public (owned by the government). This coexistence of small and big holdings raises the interesting question of economies of scale. All the major tree crops (oil palm, rubber, coffee, cacao, coconut, and tea) are harvested by hand and require a continuous harvesting at frequent time intervals almost the year around. Because the harvest labor constitutes an important cost item, the scope for scale economy is reduced. Furthermore, the difficulty of monitoring large groups of hired labor in the harvest produces negative economies, which plantations try to minimize by innovations in the approach to labor management. The positive economies of scale come from the processing plants. They are not divisible and require a continuous product supply. This is achieved by joint ownership of plantations and processing plants. Beyond this, there seem to be economies of scale in the acquisition and the development of new land and the finance allocated to these activities.

RESOURCE CONSTRAINT

Capital scarcity - The various episodes suggest a serious capital constraint to the development of agriculture. This is consistent with the relatively high shadow value for the user cost of capital. This may explain the fast growth of capital in agriculture as can be seen in Figure 3.1. It is clear that the level of capital in the 1960s was relatively low and the plot of capital shows accelerated growth in part of the period. In spite of this growth, the capital-output was still relatively low for most of the period, and this is reflected in the low factor share of capital.

The credit markets are not well developed, they hardly exist for long-run investment in agriculture. But also they are not well developed for short-term loans. This can be judged by barter arrangement between the suppliers of fertilizers and the farmers, which imply a relatively high rate of interest. This results in underutilization of fertilizers. For instance, the cacao yield in smallholder farms in Sulawesi can be increased considerably by increasing the dose of fertilizers.

To sum up the discussion, considerable growth can take place in agriculture with the expansion of conventional factors. This is in fact consistent with past performance where our calculations show that total factor contributed 55 to 60 percent of the growth in agriculture.

4. Agricultural productivity - Philippines

BACKGROUND

According to Baliscan, Debuque, and Fuwa, the study period can be divided to two distinct periods: 1960-70s, a period of good performance in the economy and in agriculture, and the 1980-90s, a period of volatility, including recessions, inflation, and political instability and changing policy measures. It is well summarized by the fact that per capita income in 1996 was roughly the same as that in 1981, indicating a waste of two decades of growth.

The production growth rates for virtually all crops decelerated in the 1980s and the early half of the 1990s. This is attributed to: 1) a decline in the expansion of cultivated area; 2) the drop in world commodity prices; 3) a series of natural calamities and droughts; 4) the virtual completion of the green revolution by the early 1980s; and 5) policy related factors, including the policy uncertainty regarding the Comprehensive Agrarian Reform Program (CARP) and the sharp decline in public investments in agriculture.

Most of the growth in rice is due to yield, and this tapered off in 1980-97. This is attributed to the decline in world price of rice, stagnation in public investment in irrigation, exhaustion of productivity potential of modern rice varieties, and soil erosion. The share of rice-harvested area under irrigation expanded at 2.6 percent in the mid 1960s to the early half of the 1990s. Irrigated rice grew from 33 percent of rice area in 1965 to 61 percent at the start of the 1990s. In contrast to the weak performance of crop agriculture in the second period, poultry and livestock (hence livestock) showed a robust growth of 5-6 percent.

DATA PATTERNS

The variables examined in the analysis, their labels, and their growth rates are listed in Table 4.1.[20] The growth rates are the trend coefficients expressed in percent. The inputs and output are plotted in Figure 4.1, and the correlation coefficients are presented in Table 4-A. The quantities (inputs, output and infrastructure) are trended upward. This is reflected in the strong correlation between these variables. On the other hand, there is a weak correlation between the quantities and the market variables: real agricultural price, its spread, and inflation. The price increased up until 1975 and then started a decline. The price fluctuated as shown by the price spread variable. Inflation spiked several times, with a peak in 1984. We also looked at unemployment, which reached a bottom in 1974 and climbed up gradually thereafter.[21] The unemployment variable and the price variables support the assertion that the 1960s and 1970s differed from the 1980s and 1990s.

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[20] We used natural logarithms except when noted with a star. The rates of growth are obtained from a trend regression. For the starred variables, the values are the trend coefficients in terms of the original units (percentage points).

[21] Unemployment is calculated as the difference between labor and employment. This is divided by labor to obtain the unemployment rate.

The empirical analysis does not sustain all the variables, and we end up eliminating electricity, roads, wages, and unemployment.

ESTIMATION

Table 4.2 presents the production function estimates with inputs alone. The irrigated land is represented here as a ratio to total land. The OLS estimates do not make sense. The signs of the PC results are fine, but not the magnitude, and the DW statistics are low. For further reference, we present in the last column the normalized values of the elasticities derived by the pc estimates. The elasticity is derived at the average value of this variable (.117).

Table 4.3 presents the PC estimates with the state variables that are retained in the analysis. The addition of the state variable did not improve in a meaningful way the DW statistics, and the estimate for the labor coefficient has the wrong sign. To overcome the low DW statistics, we compute AR regression from which we obtain the autoregressive coefficient (ρ) of 0.43. We then use this estimate to filter the variables by $[x(t) - \rho\, x(t-1)]$, and rerun the regression. The results are presented in Table 4.4. The coefficients of the PC regression all have the right sign. This result is obtained only after the introduction of the state variables, which serve as carriers of the implemented technology.

The elasticity for the irrigated land *ratio* (this variable is not logged) is the product of the ratio and its coefficient. *The ratio* varied approximately between 0.09 at the beginning of the period and 0.14 toward the end. The average value is 0.117. Thus, at the mean, the elasticity is 0.26. The sum elasticities of the remaining inputs is 0.695 and, evaluating the irrigated land *ratio* elasticity at its mean, the sum is 0.955. For *the ratio equals* 0.14 the sum becomes exactly 1, whereas at .09, the sum is closer to 0.9. Note that the coefficient of *the ratio* is partial, giving the marginal impact of increasing the share of irrigated land when other variables, and specifically total land, are constant. Thus the elasticity of the ratio indicates the premium of converting a unit of land to irrigated land. The sum elasticities of the two types of land is over .5, meaning that over one half of the value added can be attributed to land and irrigation.

The elasticity of fertilizers is around .07, in line with that obtained in the other countries. The elasticity of machines is .054 and of capital of agricultural origin (livestock and trees) is 0.093. For the period as a whole, capital shows the fastest growth after fertilizers. The growth of capital of agricultural origin extended over the whole period, whereas that of machines almost disappeared in the period 1980-1998.

The elasticity of labor is 0.165. It is difficult to judge the realism of this figure. For part of the period we have daily wages. To compute the total wage bill in agriculture on the basis of this information, it is necessary to assume the number of working days in agriculture per year. To get some idea of the share of labor in value added we assume 150 working days per year. We multiply the daily wage by 150 and by the labor figure used in the regression. The product is divided by the value added to yield the labor share. The result is plotted in Figure 4.2. The share fluctuated greatly, reaching a minimum of roughly 0.25 in the early 1980s, and a maximum of almost 0.4 in 1998. For the share to equal the elasticity, the number of working days would have to be cut by about one half.

One possibility is that we should include the efficiency or schooling of labor in the estimation. To do so, we define efficiency labor as the cross-product labor and education. Running the regression with this variable, without education as a separate variable, did not help to resolve the issue of the difference between labor share and the estimated elasticity.

The price elasticity is positive and sizable considering the fact that this is net direct response with inputs held constant. That is, it does not represent the effect of the price on inputs. The spread has a negative effect, as does inflation. These results are fairly robust. This is extremely interesting, not only because of the theory but also because these variables represent the non-trended part of the data while output is trended upward. The results for Thailand and Indonesia are weaker. The main difference between the countries is in that there was much larger price and inflation variability in the Philippines. As such, it is possible to capture the price effect with greater precision.

Although the regression that we have just discussed is reasonable, it is not identical in the treatment of irrigation, and in the filtering of the variables, to the regression used for the other two countries. For purpose of comparison with the results for Thailand and Indonesia, we present in Table 4.5 two additional regressions. We present only the PC results, but include also the DW and R^2 statistics for the OLS regressions. In both regressions, the price is lagged one year and the period of analysis is reduced by one year to 1962-1998. In the first regression, irrigated land (expressed in natural logs) replaces *the irrigated land ratio* in order to obtain the estimated elasticity directly. The resulting elasticity is 0.239 as compared with a value of 0.26 obtained at the mean of the ratio from the value in Table 4.4. The second regression separates between irrigated and rainfed land. The sum of the normalized elasticities of the two types of land is 0.58, which is similar to the sum of irrigated land and agricultural land obtained in the other two regressions. The main difference is that the regression with irrigated and rainfed lands completely separated gives a lower elasticity to the irrigated land. The elasticities of all the other variables are very close in all the three regressions. Note that the regressions in Table 4.5 are in actual values, not filtered. This shows that the results in Table 4.4 are not a direct outcome of the filtering. The DW statistics in the OLS regressions does not flag serial correlation. On the other hand, the constraints imposed by the PC estimator causes a low DW statistic. Nevertheless, as indicated above, the elasticities are similar to those obtained in the filtered version and therefore provide a reasonable basis for the substantive discussion.

SHADOW PRICES

The paddy yields in the Philippines roughly doubled between the early 1960s and the 1990s (Kawagoe, Figure 5.1), and thus the impact of the green revolution was less dramatic than in Indonesia. This might be related to the behavior of the marginal productivity of irrigated land in the Philippines; it was lower than in Indonesia, and also did not change much over the years (Figure 1.6). The level is affected by the choice of the elasticity. Had we used the value of Table 4.4, the level would have been higher, but still below that of Indonesia, and the time pattern would have remained the same. On the other hand, the marginal productivity of rainfed land is higher than in the other countries and also showed the fastest growth (Figure 1.9). Consequently, the ratio of the marginal productivity of irrigated to rainfed land declined from 3.7 in 1961 to 2.3 in 1998. Like for Thailand, the decline is likely to reflect an increase in the productivity of rainfed land caused by the introduction of new crops and overall practices. On the other hand the expansion of irrigated land might have caused a decline in its productivity on the margin because the new land brought under irrigation may be of lower quality compared to the prevailing irrigated land. Similarly, the expansion due to the increase in irrigated land may lead to lower value crops.

The gap between the marginal productivity of fertilizers and their official price, or the distortion, was high in the early 1960s, and declined gradually thereafter (Figure 1.5). It is lower than in Indonesia, but higher than in Thailand from 1971 on. As indicated in the foregoing discussion, the distortion is related to excess demand evaluated at the official prices. The decline in the distortion is probably the result of the high growth rate of fertilizers use, which exceeded considerably the rates of the other inputs. The pattern of fertilizers use would have looked completely different under perfectly elastic supply of fertilizers throughout the sample period. An inspection of the relationships between the real price of fertilizers and the price of corn or rice supports this view. The behavior of this price ratio is shown in Figure 4.2. The fertilizer is ammonium sulphate, the corn is white corn, and the rice is the special variety. A comparison of the real price of fertilizers (Figure 4.3) and the use of fertilizers (Figure 4.1) shows that while the prices fluctuated, the supply was moving upward continuously. Furthermore, the use was climbing when the real price was rising. A logarithmic regression of fertilizers use on the real price of fertilizers (corn as a numeraire) gives a positive elasticity of .5 with an R^2 of .78. This result is consistent with a continuous excess demand for fertilizers. The decline in the price of fertilizers in the 1980s resulted in a rise in the distortion rate.

The marginal productivity of capital of agricultural origin was in the .16-.18 range in 1961-1981. Thereafter, it started to decline gradually to .11 in 1998. Assuming a depreciation rate of 5 percent, the shadow value of the interest rate declined from 13 to 6 percent. The decline may be attributed to the continuous rise in the capital stock at a high rate on the one hand and the deterioration in the performance of agriculture after 1981.

A similar calculation for the user cost of capital in machines gives a very high value, which does not make sense. The problem can be detected by computing the marginal productivity of the two kinds of capital, which indicates that the marginal productivity of a peso invested in machines was 29 times higher than that invested in capital of agricultural origin. We currently have no explanation for this result.

GROWTH ACCOUNTING

The calculations in Table 1.5 of the TFP are based on the Model B estimates in Table 4.5. For the period 1961-98, total factor accounted for 90 percent of the growth in output, leaving 10 percent for TFP. The contribution of the individual inputs is fairly similar, around 15-16 percent each except for machines, which accounted for about 11 percent of the growth. The contribution of the state variables exceeded the growth of the TFP. This is mainly due to schooling in the latter period. A broader interpretation can attribute some of this impact to changes in physical infrastructure, such as electricity and roads, which were highly correlated with education and were not supported by the regression. The price variables contribute to the annual variability in output, but because their average growth rate is nearly zero, their direct contribution in the period as a whole is basically negligible.

A different picture is obtained when the exercise is conducted for the two sub-periods. The growth rate of output in the first sub-period is 3.82 percent of which 74 percent was accounted for by total factor and the remaining is due to TFP. The main contributors to the growth were rainfed land (16 percent), fertilizers (15 percent), and irrigated land (13 percent). The contribution of the other inputs was in the neighborhood of 10 percent. In the second sub-period, output grew at an average rate of only 1.38 percent, 91 percent of which is due to total factor growth. The contribution came from almost all the inputs, with the exception of machines. It is very clear that the second sub-period is inferior in the growth of total factor and of output.

There is a considerable difference in the effect of the state variables, particularly the price, in the two periods. In the first sub-period, the favorable price accounted for about 15 percent of the growth in output, more than the 8 percent that was attributed to schooling. In addition, the price volatility had a negative effect, which amounted to 2.6 percent of the output growth. In the second sub-period the declining price subtracted around 16 percent of the output, and thus neutralized the positive effect in the first sub-period. This is the reason that for the period as a whole the price effect was negligible. This demonstrates the potential positive direct effect on output of a favorable price environment. In addition, there is the indirect contribution through the choice of durable inputs as well as a ratchet effect of the technique choice. The absolute effect of education was similar throughout, but its relative effect is dominating in the second sub-period because of the low TFP growth. As a result, the state variables overestimate the TFP growth in the second period, while they underestimate it in the first period. This indicates that education alone does not represent well the role of the public goods as carriers of the implemented technology. What we have here is an outcome of the fact that the regression did not sustain more variables of this group.

The most striking result is the decline of the TFP growth rate from 0.98 percent in the first period to only 0.13 percent in the second one. The choice of the elasticities in Table 4.5 for the calculation was explained before. The question is how sensitive are the results to this choice. To answer this, we present in Table 4.7 results based on the elasticities from model A in Table 4.5. The main difference is the weights of rainfed and irrigated land. The elasticities from model B give more weight to irrigated land and less to rainfed land. The main difference in the overall results is that TFP now accounts for 14.4, rather than 10 percent, of the output growth in the period as a whole, and 31, rather than 26 percent in the first sub-period. In the second sub-period the results are similar in the two versions. The overall picture remains the same, and specifically the contribution to the slowdown in the second period. There are several possible culprits for this slow down of growth. To a large degree, this might be a reflection of the declining impact of the new varieties, and the declining profitability as measured by the real agricultural price.

Because the new varieties are intensive users of fertilizers and irrigation, these inputs immediately became scarce in the sense that their shadow price exceeded the quoted market price. The scarcity generated an increase in the supply of these inputs, so that they expanded much faster in the first period compared with the second period.

Fertilizers continued to grow at a fast rate, but less than in the first period. Exceptions are capital of agricultural origin and labor. The rise of capital of agricultural origin reflects the continuous rise in the demand for livestock product. The rise in the labor force reflects the growth in the labor force associated with the rate of population growth, and the failure of non-agriculture to absorb the growing labor supply. If this is indeed the explanation, the question is why then the TFP accounts for only 26 (Table 1.5) or 31 (Table 4.7) percent of the output growth in the first period? The answer is that part of the impact of the technical change generated by the new varieties is reflected in the shadow price of the scarce inputs, and this contributes to the growth of the TF and not of TFP.

OTHER POSSIBLE EFFECTS

Demand and export

In a closed economy, output is affected by domestic demand. In an open economy, the world market constitutes another demand component. A plot of the share of export in per capita production show that early in the study period exports reached high values. Later on, there is a declining trend of this ratio, which was converging to 10 percent.

To trace the behavior of domestic demand, we run a regression of ln per capita output in agriculture on total per capita output. The estimated elasticity is 0.6. Allowance for export has a negligible effect. This elasticity is the pseudo-income elasticity. This equation summarizes the population and income effect on the demand for the agricultural product. Adding the price ratio to the regression had little effect. Food is not identical with the agricultural product, but it accounts for most of it. Thus, the elasticity is a rough estimate for the income elasticity for food. The point is that if production is oriented largely to the domestic market, then the demand has an effect on production.

Land tenancy

Census data point at two pertinent developments in the farm operation, which may affect productivity. The results are summarized in Figure 4.3. It appears that the proportion of farms operated by non-owners (tenanted or leased) declined during the study period from over 35 percent to about 15 percent. At the same time, there is a considerable decline in the farm size. It is basically impossible to measure the impact of these changes within the empirical framework used above with any reasonable precision. It is sometimes believed that tenanted farms are less efficient. In this case, the productivity should have been higher in the second sub-period, but this is not the case. The impact of the farm size might be a partial explanation. Since much of the production is done on small farms, which are subject to increasing returns to scale, the increase in the concentration of production on small farms might have contributed to the declining productivity.

5. Appendix: Data Sources for Production Function Study

THAILAND

Gross Domestic Product (Agricultural, Total) – The agricultural GDP series includes Forestry and Fishery, but does not include Simple Agricultural Processing Products. National income accounts were obtained in constant and current market prices (baht) from the Office of The National Economic and Social Development Board (NESDB).

Agricultural Land – Data on land utilization (area) were reported by the Office of Agricultural Economics in *Land Utilization of Thailand 1950/51-1977/78, Land Utilization for Agriculture in Thailand,* and *Agricultural Statistics of Thailand.*

Irrigated Land – Data on the area (in rai) of water resources development for the Whole Kingdom have been reported since 1979 in *Agricultural Statistics of Thailand.* Data for earlier years were obtained from Wilat Nithiwathananon (1993), with the original source of the data being the Royal Irrigation Department.

Fertilizers – Agricultural Statistics of Thailand reports the data series on the volume (in metric ton) of chemical fertilizers used for agriculture.

Gross Capital Stock (Agricultural, Public Sector) – Data on the value (in 1988 and current baht) of capital stock by industry are reported in *Capital Stock of Thailand 1970-1996* by the NESDB. Capital stock data are also broken down into public and private sector.

Employment (Agricultural) – Data on employment come from the National Statistical Office, *Report of the Labor Force Survey.* Round 2 (July-September) was used for 1971-1983, and Round 3 (August) was used from 1984 on.

Farm Price – Data on the farm price of rice (in baht per metric ton) are reported by the Office of Agricultural Statistics in *Agricultural Statistics of Thailand.*

Consumer Price Index – Data on the consumer price index for the Whole Kingdom come from the Department of Business Economics, Ministry of Commerce (as reported in *Statistical Yearbook, Thailand*), with the exception of data for 1971 which was calculated using data from the World Development Indicators (WDI) of the World Bank. Data were converted to a base year of 1988.

Wage data – Data on agricultural wages were obtained from the website of Ian Coxhead (http://www.aae.wisc.edu/coxhead/projects/lamyai/data/national/). The original source of the data was the *Labor Force Survey* of the National Statistical Office (Round 2 for 1977-1983 and Round 3 for 1984-1998). Data before 1977 was estimated.

Fertilizer Prices – Data on the price of ammonium sulphate (in local currency per metric ton) were downloaded from the statistical databases on the FAO's website.

Foreign Exchange Rate – Data on the nominal foreign exchange rate (baht per US$) were available from the Bank of Thailand (as reported in *Statistical Yearbook, Thailand*).

Schooling – Economy-wide human capital is proxied by the mean school years of education of the total labor force. This data series was constructed by Nehru, Swanson, and Dubey (1993) from enrollment data using the perpetual inventory method and is available up to 1987. Data for 1988-1995 are forecast by fitting the series using an OLS regression of human capital on time.

Educational Attainment of Employed Persons (Agriculture) – Data on employed persons by level of educational attainment and industry come from the National Statistical Office, *Report of the Labor Force Survey.* Round 2 (July-September) was used for 1971-1983, and Round 3 (August) was used from 1984 on.

Infant Mortality Rate – The number of infant deaths per 1000 live births was available from the Office of the Permanent Secretary for Public Health, Ministry of Public Health, as reported in *Statistical Yearbook, Thailand.* Data from 1986-1995 were obtained from the Health Information Division, Bureau of Health Policy and Planning of the Ministry of Public Health's website.

Length of Highways – Data on the length of highways (in kilometers) for the Whole Kingdom of Thailand were obtained from the Department of Highways, Ministry of Transport and Communication, as reported in *Statistical Yearbook, Thailand.*

Electricity – Data on the amount of electricity generated (in kilowatt hours) were obtained from the National Energy Administration, Ministry of Science, Technology and Environment, as reported in *Statistical Yearbook, Thailand.*

INDONESIA

Gross Domestic Product (Agricultural, Total) – The GDP series in current and constant prices were obtained from various issues of *Statistik Indonesia* (the Statistical Yearbook of Indonesia), Badan Pusat Statistik (BPS). The agricultural GDP series used for output includes Forestry & Fishery, while that used to calculate the agricultural GDP deflator does not.

Agricultural Land – Data on the area (in hectares) of agricultural land were downloaded from the statistical databases on the FAO's website.

Irrigated Land – Data on the area (in hectares) of irrigated land were downloaded from the statistical databases on the FAO's website.

Fertilizers – Data on the consumption of fertilizers (in metric tons) were downloaded from the statistical databases on the FAO's website.

Agricultural Capital – The agricultural capital data series was estimated using the method of Larson, Butzer, Mundlak, and Crego (2000). Data on approved investment (both domestic and foreign) in agriculture, fishery, and forestry were used to calculate the capital stocks. These were obtained from the Indonesian Financial Statistics, Bank Indonesia as reported in *Statistik Indonesia.* Data on approved foreign investment are reported in US $ and were converted to rupiahs using the nominal market exchange rate (*International Financial Statistics,* International Monetary Fund). The investment data were converted to constant values using the agricultural, fishery, and forestry GDP deflator before aggregating to the capital stock series.

Agricultural Labor – Data on the total economically active population in agriculture were downloaded from the statistical databases on the FAO's website.

Educational Attainment of Employed Persons (Agriculture) – Data on employed persons by level of educational attainment and industry come from the *National Labor Force Survey*, as reported in *Statistik Indonesia.* Straight-line interpolation was used to estimate data for the missing years of 1977, 1979, 1983-1984, and 1994. Missing data for 1961-1970, 1972-1975, and 1998 were estimated by fitting the series using an OLS regression on the schooling series.

Schooling – Economy-wide human capital is proxied by the mean school years of education of the total labor force. This data series was constructed by Nehru, Swanson, and Dubey (1993) from enrollment data using the perpetual inventory method and is available up to 1987. Data for 1988-1998 are forecast by fitting the series using an OLS regression of human capital on time.

Total Road Length – Data on total road length (in kilometers) were obtained from the Directorate General for Road Construction, Provincial and Regency Public Work Offices, as reported in *Statistik Indonesia.*

Infant Mortality Rate – Data on the number of infant deaths per 1000 live births were reported in the World Development Indicators (WDI) of the World Bank for the following years: 1962, 1967, 1970, 1972, 1977, 1980, 1982, 1985, 1987, 1990, 1992, 1995-96. Straight-line interpolation was used to estimate figures for the missing years. Data for 1997-98 were estimated using annual changes in the infant mortality series obtained from the BPS.

Wholesale Price Indices – Data on wholesale price indices are reported for various sectors (including agriculture) in addition to a general index by BPS in *Statistik Indonesia.*

Consumer Price Index – Data on the consumer price index of 17 capital cities in Indonesia are reported in the *International Financial Statistics* of the IMF. Data were converted to a base year of 1993.

Wage data – Data on average wages per year by labor force classifications (including paid and unpaid agricultural employees) are reported in *Statistik Indonesia* for 1975, 1980, 1985, 1990, 1993, 1995, and 1998. Agricultural wages are calculated as averages of wages to paid and unpaid agricultural employees. Straight-line interpolation was used to estimate figures for the missing years. Data prior to 1975 was backcast using a regression of agricultural wages on agricultural productivity.

Fertilizer Prices – Data on the price of ammonium sulphate (in local currency per metric ton) were downloaded from the statistical databases on the FAO's website.

PHILIPPINES

Gross Domestic Product (Agricultural, Total) – The agricultural GDP series includes Forestry and Fishery. National accounts were obtained in constant and current market prices (pesos) from the Economic and Social Statistics Office, National Statistical Coordination Board (NSCB).

Agricultural Land – Data on the area (in hectares) of agricultural land were downloaded from the statistical databases on the FAO's website.

Irrigated Land – Data on the area (in hectares) of irrigated land were downloaded from the statistical databases on the FAO's website.

Fertilizers – Data on the consumption of fertilizers (in metric tons) are reported by the Fertilizer and Pesticide Authority.

Capital Stock in Agricultural Machines – The data series on the agricultural capital stock in agricultural machines was estimated using the method of Larson, Butzer, Mundlak, and Crego (2000). Data on gross domestic capital formation in agricultural machinery and tractors were used to calculate the capital stocks. These data are reported in current pesos in the *Philippine Statistical Yearbook.* The investment data were converted to constant values using the agricultural, fishery, and forestry GDP deflator before aggregating to the capital stock series.

Capital Stock in Livestock and Orchards – The data series on the agricultural capital stock in livestock and orchards was estimated using the method of Larson, Butzer, Mundlak, and Crego (2000). Data on capital formation in breeding stock and orchard development were used to calculate the capital stocks. These data were obtained in constant and current market prices (pesos) from the Economic and Social Statistics Office, National Statistical Coordination Board (NSCB).

Labor (Total) – Labor force data were obtained from the *Philippine Statistical Yearbook.* The original source was the Bureau of the Census and Statistics' (BCS) *Survey of Households*, which later became the National Statistics Office (NSO) conducting the *Labor Force Survey.* When available, data from the October survey were used.

Employment (Agricultural and Total) – Data on employment come from the *Labor Force Survey*, National Statistics Office, as reported in the *Philippine Statistical Yearbook.* When available, data from the October survey were used. Sectoral data were not reported in 1964, 1969, and 1979. For these years, the ratios of sectoral employment to total employment were estimated using straight-line interpolations. Agricultural employment figures were then calculated from these estimates.

Schooling – Economy-wide human capital is proxied by the mean school years of education of the total labor force. This data series was constructed by Nehru, Swanson, and Dubey (1993) from enrollment data using the perpetual inventory method and is available up to 1987. Data for 1988-1998 are forecast by fitting the series using an OLS regression of human capital on time.

Consumer Price Index – Data on the consumer price index are compiled by the Central Bank of the Philippines and reported in the *Philippine Statistical Yearbook.* For 1970-1998, data from the *World Development Indicators* of the World Bank were used. Data were converted to a base year of 1985.

Agricultural Wage Rate – Data on daily nominal wage rates in agriculture for 1969-1998 were obtained from the Bureau of Agricultural Statistics. These are simple averages of wages received by palay, corn, coconut and sugarcane farm workers. The data for 1962-1968 were reported by Boyce (1993) and used by Baliscan, Debuque, and Fuwa.

Fertilizer Prices – Data on the price of ammonium sulphate (in local currency per metric ton) were downloaded from the statistical databases on the FAO's website.

Electricity – Data on electricity produced (in million kilowatt hours) are reported in the *Philippine Statistical Yearbook.* The original source for the data up to 1973 was the National Power Cooperation/Manila Electric Company, compiled by the Utilities Division, National Census and Statistics Office; since 1973, it was the Office of Energy Affairs and then the Department of Energy. To obtain a consistent series from these different sources, an index (1980=100) was constructed applying the rates of change from the original series.

Total Road Length – Data on total road length (in kilometers) were obtained from the Department of Public Works and Highways, as reported in the *Philippine Statistical Yearbook.*

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TABLES

Table 1.1: Selected growth rates for Thailand, Indonesia and the Philippines

	Thailand	Indonesia	Philippines
	1961-97	1961-98	1961-98
Population	2.23	2.06	2.51
Output			
Agriculture	3.69	3.44	2.55
Total	7.10	6.39	3.61
Per capita			
Agriculture	1.46	1.38	0.04
Total	4.87	4.33	1.10
Agriculture/Total	0.30	0.32	0.04

Table 1.2: Growth rates in agricultural output and inputs

		Output	Land		Fertilizers	Labor	Capital		
			Irrigated	Rain-fed			Total	Machines	Agricultural origin
Thailand	1971-95	3.35	3.52	0.61	10.00	2.00	1.80		
	1971-81	3.78	3.82	1.36	11.50	3.75	1.00		
	1981-95	3.22	2.61	0.09	9.96	0.42	3.15		
Indonesia	1961-98	3.44	0.61	0.31	10.13	1.64	11.24		
	1961-80	3.39	0.25	-0.13	12.45	1.11	10.18		
	1980-98	3.04	0.69	0.68	3.69	1.95	12.68		
Philippines	1961-98	2.55	2.64	1.01	5.36	2.17		4.55	3.75
	1961-80	3.82	3.20	1.42	7.35	2.30		6.64	3.47
	1980-98	1.38	1.15	0.18	4.90	1.50		0.28	3.35

Table 1.3:Production function-summary results for Thailand, Indonesia and the Philippines

	Thailand	Indonesia	Philippines
	1971-1995	1980-98	1971-1998
Inputs			
Irrigated land	0.132	0.457	0.155
Rain-fed land	0.248	0.230	0.425
Fertilizers	0.061	0.084	0.077
Capital	0.415	0.031	0.163
Labor	0.144	0.198	0.181
State variables			
Price	0.034	0.127	0.320
Price spread		0.161	-0.696
Inflation	-0.323		-0.104
No schooling	-0.009	-0.003	
Education			0.213
Roads	0.096	0.073	
Infant morality	-0.004	-0.002	

Table 1.4:Productivity, prices and shadow prices.

	Thailand 1971-95		Philippines 1961-98		Indonesia 1971-98	
			A Productivity ($ 1993)			
	average	marginal	average	marginal	average	marginal
1. Irrigated land	2,670	352	6,448	1,001	5,004	2,288
2. Rainfed land	559	138	856	363	602	138
3. Fertilizers	8,760	538	10,985	842	17,793	1,493
4. Capital	0.47	0.20	1.53	0.15	3.07	0.09
5. Labor	548	79	883	160	544	108
6. Machines			92.0	5.7		
			B Reported prices ($ 1993)			
1. Wage rate		311		349		493
2. Fertilizer price		873		921		743
3. Fertilizer, distortion rate		0.62		0.91		2.01
			C Marginal rates of substitution			
1. Irrigated to rainfed land		2.54		2.75		16.54
2. Irrigated land to labor		4.47		6.27		21.21
3. Irrigated land to wages		1.13		2.87		4.64
4. Irrigated land to labor adjusted		1.55		1.59		4.88
5. Irrigated land for capital		1,784		6,516		24,353
			D Derived prices ($ 1993)			
1. Irrigated land		2,346		6,673		15,253
2. Irrigated land-capital base		2,373		8,667		32,390

Table 1.5: Sources of growth for Thailand, Indonesia and the Philippines

	elasticity	percentage chage			Share of growth		
Philippines		*1961-98*	*1961-80*	*1980-98*	*1961-98*	*1961-80*	*1980-98*
Output		2.554	3.819	1.383			
Inputs							
Irrigated land	0.155	2.636	3.200	1.147	0.160	0.130	0.129
Rainfed	0.425	1.008	1.420	0.184	0.168	0.158	0.056
Fertilizers	0.077	5.360	7.350	4.900	0.161	0.148	0.272
Capital-ag origin	0.101	3.750	3.470	3.350	0.148	0.091	0.244
Labor	0.181	2.165	2.300	1.500	0.153	0.109	0.196
Capital-machines	0.062	4.546	6.640	0.280	0.111	0.108	0.013
State variables							
Price-GDP deflators	0.320	0.000	1.750	-0.700	0.000	0.147	-0.162
Price spread	-0.696	0.030	0.144	-0.010	-0.008	-0.026	0.005
Inflation rate	-0.104	0.113	0.670	-0.636	-0.005	-0.018	0.048
Schooling	0.213	1.650	1.460	1.600	0.137	0.081	0.246
Factor accumulation		2.30	2.84	1.26	0.900	0.744	0.909
State variables					0.125	0.184	0.137
Total factor productivity		0.25	0.98	0.13	0.100	0.256	0.091
Portion of TFP due to state variables					1.251	0.717	1.507
Indonesia		*1971-98*	*1971-81*	*1981-98*	*1971-98*	*1971-81*	*1981-98*
Output		3.39	3.69	3.045			
Inputs							
Irrigated land	0.457	0.80	0.97	0.694	0.109	0.120	0.104
Rainfed land	0.230	0.52	-0.25	0.685	0.035	-0.016	0.052
Fertilizers	0.084	8.18	14.45	3.690	0.203	0.329	0.102
Capital	0.031	11.59	8.00	12.677	0.105	0.066	0.128
Labor	0.198	1.88	1.32	1.947	0.110	0.071	0.127
State variables							
Wholesale price ratio	0.127	1.36	0.84	2.370	0.051	0.029	0.098
Price spread	0.161	0.10	0.75	0.114	0.005	0.033	0.006
No schooling*	-0.003	-1.30	-1.43	-1.216	0.115	0.116	0.120
Roads	0.073	5.71	5.46	5.091	0.124	0.109	0.123
Infant mortality*	-0.002	-2.79	-2.97	-2.395	0.132	0.129	0.126
Factor accumulation		1.90	2.10	1.56	0.561	0.571	0.512
State variables					0.426	0.416	0.473
Total factor productivity		1.49	1.58	1.49	0.439	0.429	0.488
Portion of TFP due to state variables					0.971	0.969	0.968

Table 1.5 (continued)

Thailand		*1971-95*	*1971-81*	*1981-95*	*1971-95*	*1971-81*	*1981-95*
Output		3.346	3.775	3.22			
Inputs							
Irrigated land	0.132	3.520	3.817	2.612	0.139	0.133	0.107
Rainfed land	0.248	0.606	1.362	0.093	0.045	0.089	0.007
Fertilizers	0.061	10.000	11.500	9.960	0.184	0.187	0.190
Capital	0.415	1.800	1.000	3.150	0.223	0.110	0.406
Labor	0.144	2.000	3.750	0.420	0.086	0.143	0.019
State variables							
Real farm price	0.034	-1.098	2.282	-1.489	-0.011	0.021	-0.016
Inflation	-0.323	-0.280	0.670	-0.060	0.027	-0.057	0.005
No schooling*	-0.009	-0.426	-0.730	-0.248	0.115	0.174	0.069
Roads	0.096	5.100	5.876	4.440	0.146	0.149	0.132
Infant mortality*	-0.004	-0.870	-0.153	-0.436	0.099	0.015	0.051
Growth due to:							
Factor accumulation		2.26	2.50	2.35	0.676	0.663	0.729
State variables					0.375	0.302	0.242
Total factor productivity		1.08	1.27	0.87	0.324	0.337	0.271
Portion of TFP due to state variables					1.159	0.894	0.894
Alternative Thailand		*1971-95*	*1971-81*	*1981-95*	*1971-95*	*1971-81*	*1981-95*
Output		3.346	3.775	3.22			
Inputs							
Irrigated land	0.129	3.520	3.817	2.612	0.108	0.104	0.084
Rainfed land	0.286	0.606	1.362	0.093	0.041	0.082	0.007
Fertilizers	0.059	10.000	11.500	9.960	0.140	0.143	0.145
Capital	0.377	1.800	1.000	3.150	0.162	0.080	0.295
Labor	0.149	2.000	3.750	0.420	0.071	0.118	0.016
State variables							
Real farm price	0.023	-1.098	2.282	-1.489	-0.008	0.014	-0.011
Inflation	-0.295	-0.280	0.670	-0.060	0.025	-0.052	0.005
No schooling*	-0.008	-0.426	-0.730	-0.248	0.001	0.001	0.001
Roads	0.081	5.100	5.876	4.440	0.123	0.126	0.112
Electricity	0.045	10.760	11.300	11.950	0.145	0.135	0.168
Infant mortality*	-0.003	-0.870	-0.153	-0.436	0.001	0.000	0.000
Factor accumulation		2.19	2.49	2.20	0.523	0.527	0.545
State variables					0.288	0.224	0.275
Total factor productivity		1.16	1.28	1.02	0.477	0.473	0.455
Portion of TFP due to state variables					0.603	0.475	0.605

Table 2.1: Thailand growth rates

	1971-95	1971-81	1981-1995
Output	3.35	3.78	3.22
Inputs			
Land	1.10	1.72	0.58
Irrigated land	3.52	3.82	2.61
Rain-fed land	0.61	1.36	0.09
Fertilizers	10.00	11.50	9.96
Capital	1.80	1.00	3.15
Labor	2.00	3.75	0.42
Incentives			
Real farm price	-1.10	2.28	-1.49
Price ratio	-0.58	2.37	-0.94
Price spread*	-0.02	-0.53	-0.25
Inflation*	-0.28	0.67	-0.06
Real exchange rate	-5.30	-9.97	-3.08
Education			
Schooling	1.69	1.58	1.77
No schooling*	-0.43	-0.73	-0.25
Infant mortality*	-0.87	-0.15	-0.44
Infrastructure			
Roads	5.10	5.88	4.44
Electricity	10.76	11.30	11.95
Public investment*	1.60	0.88	1.70

Note: We used natural logarithms except when noted with a star. The rates of growth are obtained from a trend regression. For the starred variables, the values are the trend coefficients in terms of the original units (percentage points).

Table 2.2: Restricted production function results for Thailand, 1971-95.

	b OLS	t OLS	Normalized	b PC	t PC	Normalized
Constant	-3.461	-0.380		-7.924	-8.284	
Irrigated land	0.319	2.587	0.217	0.219	43.898	0.130
Rain-fed land	0.399	1.170	0.272	0.664	9.148	0.394
Fertilizer	0.070	1.350	0.048	0.083	35.325	0.049
Capital	0.438	2.827	0.298	0.485	12.189	0.288
Labor	0.243	2.208	0.165	0.233	12.524	0.139
Sum	1.469		1.000	1.683		1.000
Rank				2		
DW	2.148			2.175		
R^2	0.989			0.989		

Table 2.3: Production function results with added state variables for Thailand, 1971-95

	b PC	b PC	Normalized
Constant	5.175	8.073	
Irrigated land	0.137	39.317	0.146
Rain-fed land	0.255	3.737	0.271
Fertilizer	0.055	24.296	0.058
Capital	0.388	9.308	0.413
Labor	0.105	5.924	0.111
Sum	0.940		1.000
No schooling	-0.009	-23.970	
Roads	0.102	31.108	
Infant mortality	-0.004	-23.099	
Rank	2		
DW	1.851		
R^2	0.987		

Table 2.4:Base model results for Thailand, 1971-95

	b PC	t PC	Normalized
Constant	5.830	9.19	
Irrigated land	0.120	31.01	0.132
Rain-fed land	0.225	2.73	0.248
Fertilizers	0.056	16.21	0.061
Capital	0.377	7.48	0.415
Labor	0.131	9.97	0.144
Sum	0.908		1.000
Real farm price	0.034	1.13	
Inflation	-0.323	-14.50	
No schooling	-0.009	-32.89	
Roads	0.096	27.52	
Infant mortality	-0.004	-16.46	
Rank	2		
DW	1.748		
R^2	0.982		

Table 2.5: Thailand: Productivity, prices and shadow prices, various periods.

		Thailand 1971-95		Thailand 1971-81		Thailand 1981-91	
	e	average	marginal	average	marginal	average	marginal
				A Productivity ($ 1993)			
1. Irrigated land	0.132	2,670	352	2,745	362	2,611	344
2. Rainfed land	0.248	559	138	456	113	632	156
3. Fertilizers	0.061	8,760	538	12,749	783	5,869	361
4. Capital	0.415	0.47	0.20	0.42	0.17	0.52	0.22
5. Labor	0.144	548	79	502	72	576	83
				B Reported prices ($ 1993)			
1. Wage rate			311		285		328
2. Fertilizer price			873		1,128		696
3. Fertilizer, distortion rate			0.62		0.69		0.52
				C Marginal rates of substitution			
1. Irrigated to rainfed land			2.54		3.21		2.20
2. Irrigated land to labor			4.47		5.01		4.15
3. Irrigated land to wages			1.13		1.27		1.05
4. Irrigated land to labor adjusted			1.55		1.74		1.44
5. Irrigated land for capital			1,784		2,095		1,599
				D Derived prices ($ 1993)			
1. Irrigated land			2,346		2,411		2,294
2. Irrigated land-capital base			2,373		2,787		2,127

Table 2-6:Base model results for Thailand with electricity added, 1971-1995

	b OLS	t OLS	b PC	t PC
Constant	12.545	0.870	7.486	12.734
Irrigated land	0.238	0.813	0.103	27.251
Rainfed land	-0.025	-0.055	0.229	3.075
Fertilizers	-0.053	-0.589	0.047	17.947
Capital	-0.012	-0.037	0.301	7.421
Labor	0.293	1.520	0.119	10.091
Sum	0.442		0.799	
Real farm price	0.022	0.345	0.023	0.801
Inflation	-0.003	-0.014	-0.295	-11.252
No schooling	-0.003	-0.395	-0.008	-29.474
Roads	-0.105	-0.534	0.081	33.986
Electricity	0.297	1.621	0.045	15.998
Infant mortality	0.003	0.761	-0.003	-13.757
Statistical Rank	2			
Sig. level for rank test	0.05			
DW for orig regression	2.27			
R^2 for orig regression	0.99			
DW for pc regression	1.88			
R^2 for pc regression	0.98			

Table 3.1: Indonesian growth rates

	1961-98	1961-80	1971-98	1971-81	1980-98
Output	3.44	3.39	3.39	3.69	3.04
Inputs					
Irrigated land	0.61	0.25	0.80	0.97	0.69
Rainfed land	0.31	-0.13	0.52	-0.25	0.68
Fertilizers	10.13	12.45	8.18	14.45	3.69
Capital	11.24	10.18	11.59	8.00	12.68
Labor	1.64	1.11	1.88	1.32	1.95
Incentives					
Price-GDP deflators	-1.48	-1.24	-1.58	-2.91	-0.59
Wholesale price ratio	-		1.36	0.84	2.37
Price spread			0.10	0.75	0.11
Inflation*	-6.49	-17.63	-0.13	-1.32	0.78
Education					
Schooling	3.73	4.01	3.63	3.49	3.84
No schooling*	-1.81	-2.81	-1.30	-1.43	-1.22
Infant mortality*	-2.60	-2.10	-2.79	-2.97	-2.40
Infrastructure					
Roads	4.92	3.09	5.71	5.46	5.09

Table 3.2: Indonesian production function estimates

	1971-98				1980-98			
	b OLS	t OLS	b PC	t PC	b OLS	t OLS	b PC	t PC
Constant	-16.057	-2.246	-5.743	-1.493	-29.255	-4.476	-35.817	-5.654
Irrigated land	0.403	1.437	0.171	0.700	0.868	3.025	1.389	9.236
Rain-fed land	-0.163	-1.328	-0.194	-1.567	0.029	0.327	0.115	1.350
Fertilizer	0.078	4.790	0.095	45.303	0.028	0.559	0.108	2.949
Capital	0.011	0.210	0.103	11.812	-0.060	-1.287	-0.088	-1.799
Labor	1.258	3.946	0.727	9.344	1.580	5.244	1.398	4.373
Sum			0.903				2.923	
Rank			3				4.	
DW	1.844		1.830		1.957		1.850	
R^2	0.996		0.995		0.996		0.995	

Table 3.3: Production function results with added state variables for Indonesia

	1971-98			1980-98		
	b PC	t PC	Normalized	b PC	t PC	Normalized
Constant	-7.482	-7.937		-8.380	-22.215	
Irrigated land	0.662	27.764	0.624	0.729	14.457	0.647
Rain-fed land	0.059	0.808	0.056	0.057	1.312	0.050
Fertilizer	0.056	42.700	0.053	0.076	16.771	0.067
Capital	0.040	78.728	0.037	0.037	40.134	0.033
Labor	0.244	78.327	0.230	0.228	50.562	0.202
Sum	1.061		1.000	1.127		1.000
No education	-0.004	-77.994		-0.003	-39.037	
Roads	0.083	70.113		0.083	51.289	
Infant mortality	-0.002	-45.334		-0.002	-30.003	
Rank	2			2		
DW	1.80			1.78		
R^2	1.00			0.99		

Table 3.4: Base model results for Indonesia

	Model A		Model B	
	1971-98		1980-98	
	b PC	t PC	b PC	t PC
Constant	-6.344	-6.327	-6.747	-15.611
Irrigated land	0.583	27.405	0.463	40.769
Rain-fed land	0.080	1.071	0.233	40.769
Fertilizer	0.066	16.448	0.085	40.769
Capital	0.035	39.986	0.031	40.769
Labor	0.227	59.221	0.201	40.769
Sum	0.990		1.012	
Wholesale price ratio	0.057	1.697	0.127	40.769
Price spread	0.069	0.472	0.161	40.769
No education	-0.003	-55.029	-0.003	-40.769
Roads	0.084	43.561	0.073	40.769
Infant mortality	-0.002	-39.341	-0.002	-40.769
Rank	4		1	
DW	1.88		1.25	
R^2	1.00		0.99	

Table 3.5: Indonesia production function, average productivity of irrigated land, 1971-98

	Model C		Model D	
	b PC	t PC	b PC	t PC
Constant	-6.729	-45.999	-6.624	-66.486
Irrigated land*	0.518		0.524	
Rain-fed land	-0.018	-0.324	-0.003	-0.081
Fertilizer	0.051	62.984	0.050	46.426
Capital	0.041	61.194	0.038	53.177
Labor	0.408	35.878	0.391	35.813
Wholesale price ratio			0.123	14.310
Price spread			-0.198	-2.402
No education	-0.003	-57.936	-0.003	-48.745
Roads	0.077	63.289	0.073	49.782
Infant mortality	-0.002	-58.130	-0.001	-54.864
Rank	2		2	
DW	1.861		1.396	
R^2	0.994		0.992	

* calculated from homogeneity constraint.

Table 3.6: Indonesia: Productivity, prices and shadow prices

	A Productivity ($ 1993)						
		1971-98		1971-81		I 1981-98	
	e	average	marginal	average	marginal	average	marginal
1. Irrigated land	0.457	5,004	2,288	3,903	1,785	5,644	2,581
2. Rainfed land	0.230	602	138	460	106	686	158
3. Fertilizers	0.084	17,793	1,493	27,591	2,314	11,544	968
4. Capital	0.031	3.07	0.09	5.01	0.15	1.91	0.06
5. Labor	0.198	544	108	474	94	586	116
	B. Reported prices ($ 1993)						
1. Wage rate			493		328		592
2. Fertilizer price			743		943		606
3. Fertilizer, distortion rate			2.01		2.45		1.60
	C. Marginal rates of substitution						
1. Irrigated to rainfed land			16.54		16.89		16.36
2. Irrigated land to labor			21.21		18.97		22.21
3. Irrigated land to wages			4.64		5.45		4.36
4. Irrigated land to labor adjusted			4.88		4.37		5.11
5. Irrigated land for capital			24,353		11,629		44,013
6. Irrigated land for capital adjusted			5,606		2,677		10,131
	D. Derived prices ($ 1993)						
1. Irrigated land			15,253		11,898		17,205
2. Irrigated land-capital base			32,390		15,466		58,538

Table 3.7: Sources of growth for Indonesia

	1971-98	Model A (1971-98)		Model B (1980-98), normalized		Model D (1971-98)	
	growth	growth	proportion	growth	proportion	parameter	proportion
Output	3.386						
Inputs							
Irrigated land	0.804	0.583	0.138	0.457	0.109	0.524	0.124
Rainfed land	0.516	0.080	0.012	0.230	0.035	-0.003	-0.000
Fertilizers	8.176	0.066	0.158	0.084	0.203	0.050	0.120
Capital	11.592	0.035	0.119	0.031	0.105	0.038	0.130
Labor	1.884	0.227	0.126	0.198	0.110	0.391	0.218
State variables							
Wholesale price ratio	1.355	0.057	0.023	0.127	0.051	0.123	0.049
Price spread	0.100	0.069	0.002	0.161	0.005	-0.198	-0.006
No schooling*	-1.301	-0.003	0.131	-0.003	0.115	-0.003	0.123
Roads	5.713	0.084	0.142	0.073	0.124	0.073	0.124
Infant mortality*	-2.789	-0.002	0.148	-0.002	0.132	-0.001	0.115
Factor accumulation			0.554		0.561		0.591
State variables			0.446		0.426		0.406
Total factor productivity			0.446		0.439		0.409
Portion of TFP due to state variables			1.000		0.971		0.992

Note:models A and B are from table 3.4; model D is from table 3.5

Table 4.1:Growth rates in the Philippines

	1961-98	1961-80	1980-98
Output	2.554	3.819	1.383
Inputs			
Land	1.194	1.600	0.309
Irrigated land	2.636	3.200	1.147
Rainfed land	1.008	1.420	0.184
Fertilizers	5.360	7.350	4.900
Capital-machines	4.546	6.640	0.280
Capital-agricultural origin	3.750	3.470	3.350
Labor	2.165	2.300	1.500
Incentives			
Price-GDP deflators	0.000	1.750	-0.700
Price spread	0.030	0.144	-0.010
Inflation	0.113	0.670	-0.636
Wage	-0.132	-1.281	2.364
Unemployment*	0.068	-0.143	0.187
Education			
Schooling	1.650	1.460	1.600
Infrastrucutre			
Roads	3.676	6.040	0.608

Table 4.2: Philippine production function estimates, 1961-98

	b OLS	t OLS	b PC	t PC	PC-Normalized
Constant	6.72	1.88	11.75	24.56	
Irrigated land ratio	-1.64	-0.69	0.79	1.38	0.10
Land	0.64	2.65	0.38	29.58	0.43
Fertilizer	0.13	3.79	0.15	6.59	0.17
Capital-machine	0.12	3.16	0.13	7.03	0.15
Capital-agricultural origin	0.19	1.72	0.06	2.90	0.07
Labor	-0.02	-0.12	0.08	2.23	0.09
					1.01
Statistical Rank			2.00		
DW	1.01		1.08		
R^2	0.98		0.98		

Table 4.3: Philippine production function with added state variables, 1961-98.

	b PC	t PC
Constant	11.020	12.880
Irrigated land ratio	1.775	10.784
Land	0.565	8.443
Fertilizer	0.008	0.391
Capital-machine	0.055	4.023
Capital-agricultural origin	0.235	4.897
Labor	-0.178	-1.557
Education	0.474	5.522
Inflation	-0.148	-2.613
Price-GDP deflator	0.624	7.377
Price spread	-0.759	-2.528
Statistical Rank	5	
Sig. level for rank test	0.05	
DW for OLS	1.646	
R^2 for OLS	0.992	
DW for pc	1.157	
R^2 for pc	0.989	

Table 4.4: Philippine production function from filtered data, 1961-98.

	b OLS	t OLS	b PC	t PC
	Filtered variables, ρ =.43			
Constant	5.02	0.76	7.31	27.12
Irrigated land	-0.55	-0.17	2.21	27.07
Land	0.41	1.46	0.31	25.40
Fertilizer	0.02	0.95	0.07	9.06
Capital-machine	0.10	2.25	0.05	16.33
Capital-agricultural origin	0.35	0.86	0.09	21.14
Labor	-0.09	-0.69	0.16	27.25
Education	0.20	0.25	0.21	21.37
Price spread	-0.79	-2.19	-0.66	-2.50
Inflation	-0.14	-2.07	-0.04	-0.60
Price-GDP deflator	0.45	3.51	0.20	2.49
Statistical Rank			3	
Sig. level for rank test			0.050	
DW for OLS regression			2.003	
R^2 for OLS regression			0.973	
DW for pc regression			1.678	
R^2 for pc regression			0.958	

Table 4.5: Alternative specifications for the Philippine production function, 1961-98.

	Model A				Model B		
	b PC	t PC	Normalized		b PC	t PC	Normalized
Constant	13.194	46.703		Constant	9.9736	28.229	
Irrigated land	0.239	40.768	0.249	Irrigated land	0.1413	45.818	0.155
Land	0.331	30.762	0.345	Rainfed land	0.3864	27.722	0.425
Fertilizer	0.073	28.209	0.076	Fertilizer	0.0698	31.141	0.077
Capital-machine	0.057	41.449	0.059	Capital-machine	0.0566	39.107	0.062
Capital-agricultural origin	0.093	36.203	0.097	Capital-agricultural origin	0.0916	32.935	0.101
Labor	0.167	45.768	0.174	Labor	0.1645	44.555	0.181
	0.959				0.9102		1.000
Education	0.215	42.588		Education	0.2127	39.649	
Price-Gdp deflator	0.354	5.764		Price-Gdp deflator	0.3204	5.320	
Price spread	-0.862	-2.977		Price spread	-0.696	-2.440	
Inflation	-0.127	-2.756		Inflation	-0.1038	-2.255	
Statistical Rank		2			2		
Dw for OLS		1.844			1.860		
R^2 for OLS		0.990			0.991		
DW for PC		1.146			1.078		
R^2 for PC		0.984			0.984		

Table 4.6: Philippines: productivity, prices and shadow prices

	Philippines 1961-98			Philippines 1961-80		Philippines 1980-98	
	e	average	marginal	average	marginal	average	marginal
1. Irrigated land	0.155	6,448	1,001	6,617	1,027	6,292	977
2. Rainfed land	0.425	856	363	749	318	970	412
3. Fertilizers	0.077	10,985	842	13,556	1,040	8,238	632
4. Capital	0.101	1.53	0.15	1.72	0.17	1.34	0.13
5. Labor	0.181	883	160	867	157	905	164
6. Machines	0.062	92.02	5.72	120.18	7.47	60.74	3.78
B Reported prices ($ 1993)							
1. Wage rate			349		357		339
2. Fertilizer price			921		1,053		814
3. Fertilizer, distortion rate			0.91		0.99		0.78
C Marginal rates of substitution							
1. Irrigated to rainfed land			2.75		3.23		2.37
2. Irrigated land to labor			6.27		6.56		5.97
3. Irrigated land to wages			2.87		2.88		2.88
4. Irrigated land to labor adjusted			1.59		1.66		1.51
5. Irrigated land for capital			6,516		5,950		7,248
6. Irrigated land for capital adjusted			1,651		1,507		1,836
D Derived prices ($ 1993)							
1. Irrigated land			6,673		6,849		6,511
2. Irrigated land-capital base			8,667		7,914		9,640

Table 4-7: Philippines: growth accounting using alternative parameters.

	elasticity	percentage change			Share of growth		
Philippines		1961-98	1961-80	1980-98	1961-98	1961-80	1980-98
Output		2.554	3.819	1.383			
Inputs							
Portion of land irrigated	0.249	1.442	1.600	0.838	0.141	0.104	0.151
Land	0.345	1.194	1.600	0.309	0.161	0.145	0.077
Fertilizers	0.076	5.360	7.350	4.900	0.159	0.146	0.269
Capital-agricultural origin	0.097	3.750	3.470	3.350	0.142	0.088	0.234
Labor	0.174	2.165	2.300	1.500	0.147	0.105	0.189
Capital-machines	0.059	4.546	6.640	0.280	0.105	0.103	0.012
State variables							
Price-GDP deflators	0.354	0.000	1.750	-0.700	0.000	0.162	-0.179
Price spread	-0.862	0.030	0.144	-0.010	-0.010	-0.032	0.006
Inflation rate	-0.104	0.113	0.670	-0.636	-0.005	-0.018	0.048
Schooling	0.215	1.650	1.460	1.600	0.139	0.082	0.249
Factor accumulation		2.300	2.841	1.258	0.856	0.690	0.931
State variables					0.124	0.194	0.124
Total factor productivity		0.254	0.978	0.125	0.144	0.310	0.069
Portion of TFP due to state variables					0.863	0.626	1.803

Table 2-A: Correlation matrix for Thailand variables, 1971-95

	Output	Irrigated land	Rain-fed land	Fertilizers	Capital	Labor	No schooling	Human capital	Infant mortality	Roads	Electricity	Price ratio	Real farm price
Output	1.00												
Irrigated land	0.98	1.00											
Rain-fed land	0.85	0.88	1.00										
Fertilizers	0.99	0.97	0.85	1.00									
Capital	0.87	0.81	0.54	0.87	1.00								
Labor	0.89	0.90	0.87	0.87	0.59	1.00							
No schooling	-0.94	-0.94	-0.89	-0.92	-0.73	-0.89	1.00						
Human capital	0.99	0.98	0.82	0.99	0.90	0.85	-0.92	1.00					
Infant mortality	-0.92	-0.94	-0.84	-0.91	-0.72	-0.94	0.91	-0.91	1.00				
Roads	0.99	0.99	0.85	0.98	0.84	0.89	-0.94	0.99	-0.94	1.00			
Electricity	0.99	0.97	0.81	0.99	0.91	0.84	-0.91	1.00	-0.90	0.98	1.00		
Price ratio	-0.36	-0.43	-0.17	-0.36	-0.40	-0.22	0.22	-0.42	0.29	-0.39	-0.38	1.00	
Real farm price	-0.40	-0.47	-0.23	-0.38	-0.48	-0.22	0.29	-0.46	0.38	-0.43	-0.43	0.84	1.00

Table 3-A: Correlation matrix for Indonesia variables, 1971-98

	Output	Irrigated land	Rain-fed land	Fertilizer	Capital	Labor	Wholesale price ratio	Price spread	No education	Roads	Infant mortality
Output	1.000										
Irrigated land	0.961	1.000									
Rain-fed land	0.695	0.567	1.000								
Fertilizer	0.946	0.896	0.628	1.000							
Capital	0.986	0.956	0.731	0.895	1.000						
Labor	0.992	0.947	0.740	0.916	0.995	1.000					
Wholesale price ratio	0.729	0.780	0.444	0.556	0.773	0.737	1.000				
Price spread	0.267	0.355	0.081	0.200	0.263	0.228	0.517	1.000			
No education	-0.985	-0.917	-0.732	-0.934	-0.971	-0.984	-0.701	-0.229	1.000		
Roads	0.993	0.944	0.709	0.942	0.981	0.992	0.683	0.215	-0.987	1.000	
Infant mortality	-0.995	-0.974	-0.663	-0.947	-0.982	-0.987	-0.726	-0.252	0.973	-0.990	1.000

Table 4-A: Correlation matrix for Philippine variables, 1961-98

	Output	Irrigated land	Land	Fertilizer	Capital-machine	Capital-agriculture origin	Labor	Education	Inflation	Price-GDP deflator	Price spread	Unemploy-ment
Output	1.000											
Irrigated land	0.954	1.000										
Land	0.969	0.946	1.000									
Fertilizer	0.944	0.928	0.898	1.000								
Capital-machine	0.961	0.917	0.953	0.881	1.000							
Capital-agriculture origin	0.966	0.982	0.948	0.933	0.927	1.000						
Labor	0.961	0.976	0.962	0.915	0.935	0.977	1.000					
Education	0.960	0.971	0.952	0.926	0.921	0.996	0.978	1.000				
Inflation	0.195	0.204	0.188	0.128	0.272	0.146	0.186	0.121	1.000			
Price-Gdp deflator	0.155	0.007	0.071	0.126	0.147	-0.055	0.013	-0.090	0.387	1.000		
Price spread	0.240	0.185	0.187	0.245	0.299	0.179	0.177	0.153	-0.089	0.418	1.000	
Unemployment	0.303	0.432	0.320	0.346	0.198	0.476	0.359	0.473	-0.298	-0.627	-0.165	1.000

FIGURES

Figure 1-1: Land-labor ratio

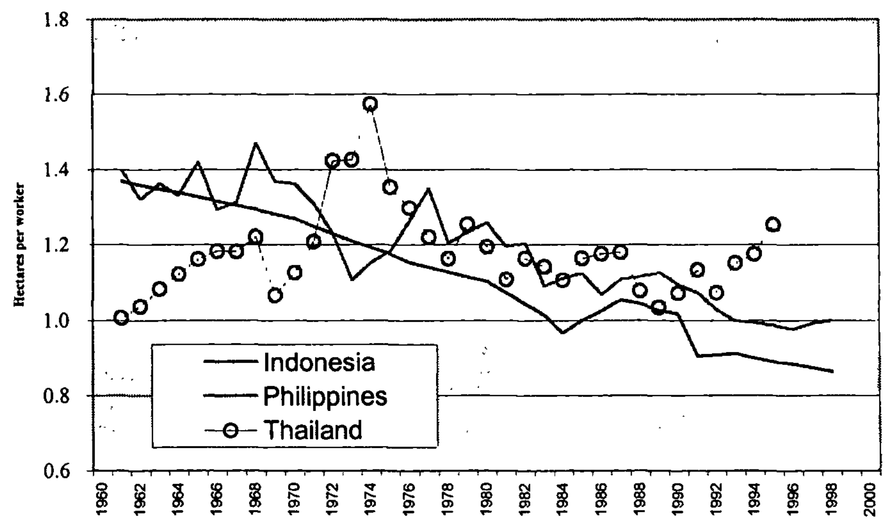


Figure 1.2 Ratio of irrigated land over agricultural land

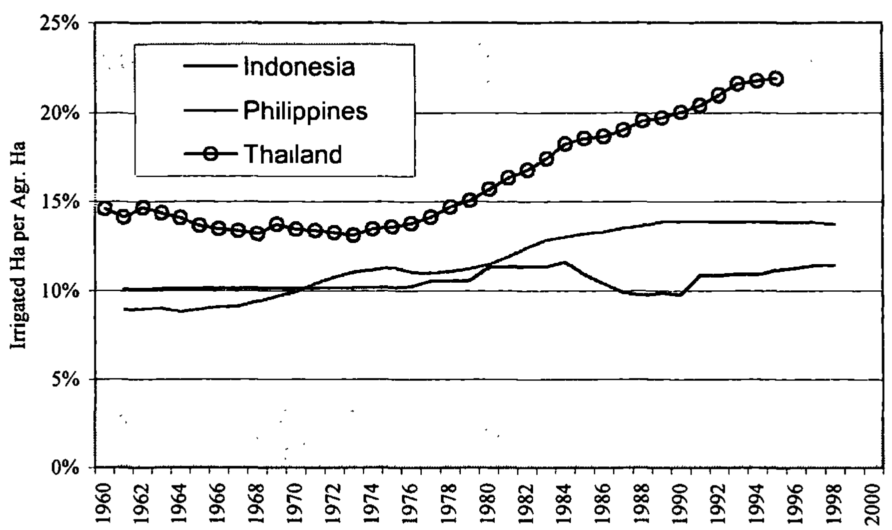


Figure 1.3 Agricultural capital over output

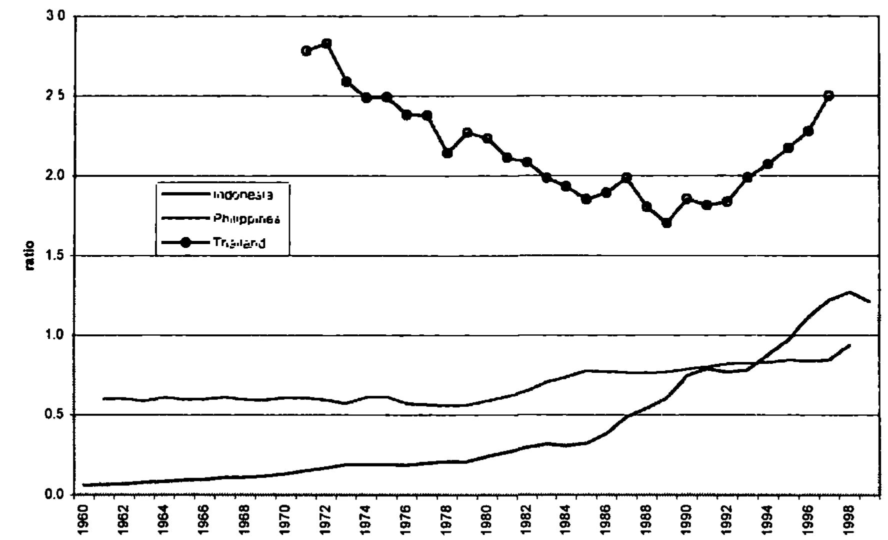


Figure 1.4 Ferilizers to land ratios

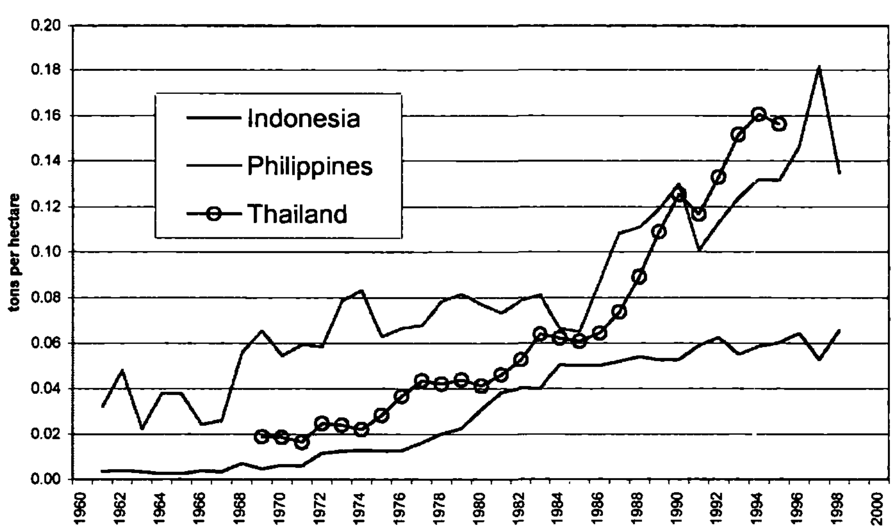
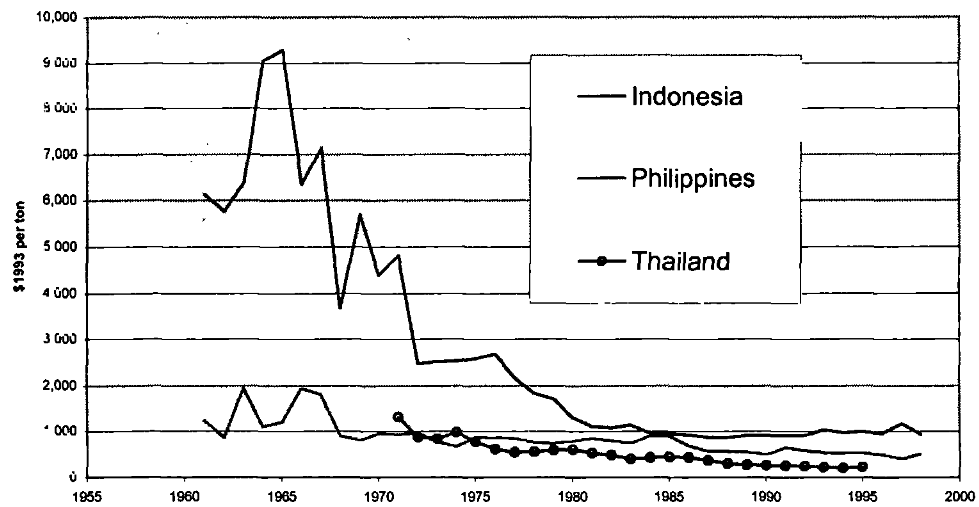
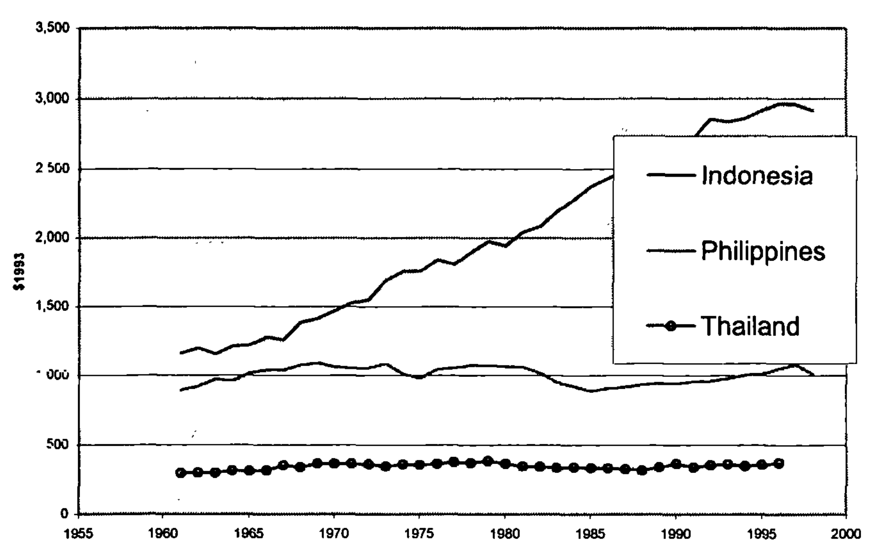


Figure 1-5 Marginal productivity of fertilizer



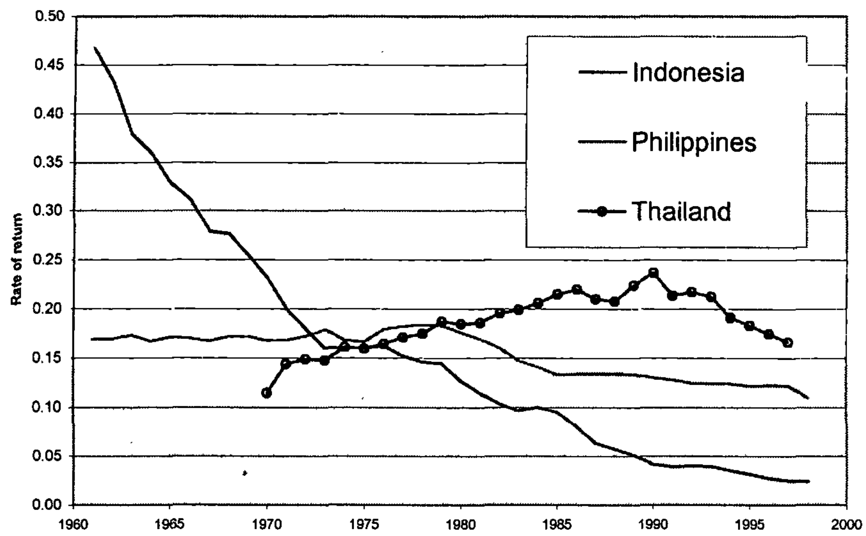
Note: The marginal productivity values are derived from the production-function parameters. See the discussion relating to table 1.4.

Figure 1-6 Marginal productivity of irrigated land



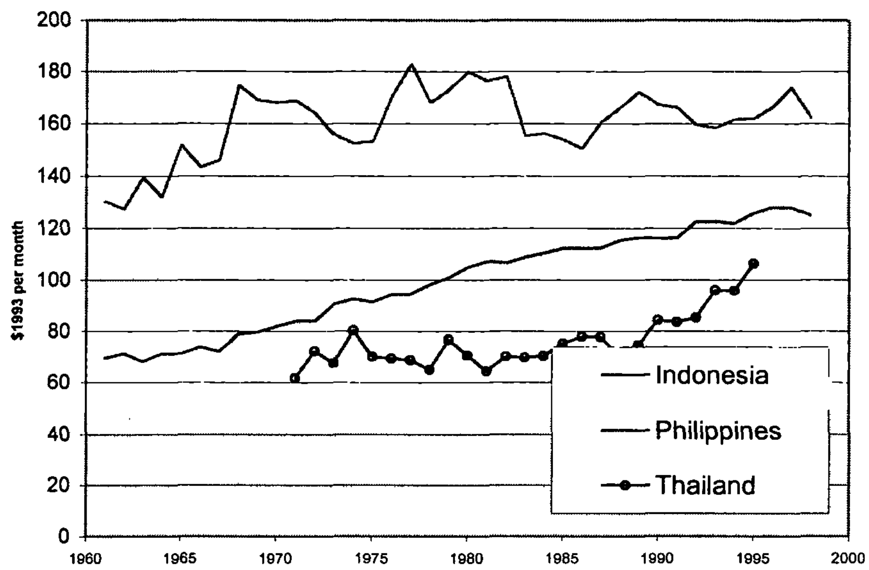
Note: The marginal productivity values are derived from the production-function parameters. See the discussion relating to table 1.4.

Figure 1.7 Marginal productivity of capital



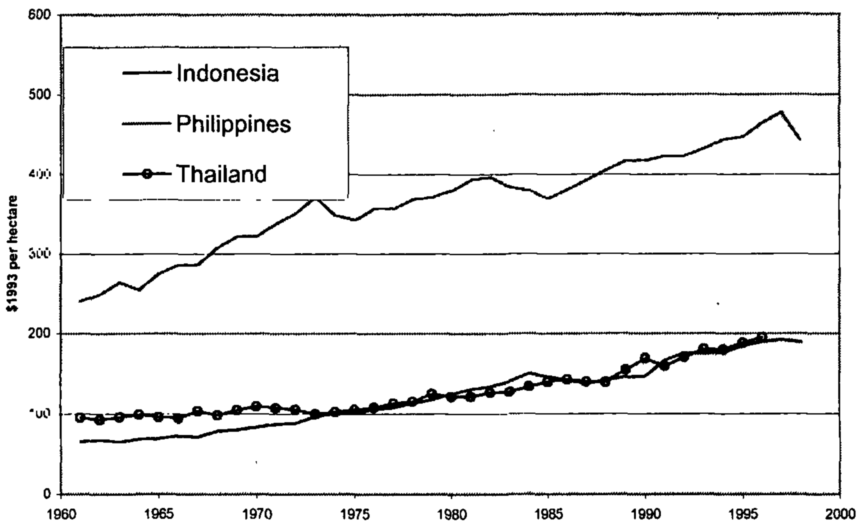
Note: The marginal productivity values are derived from the production-function parameters. See the discussion relating to table 1.4.

Figure 1.8 Marginal productivity of labor



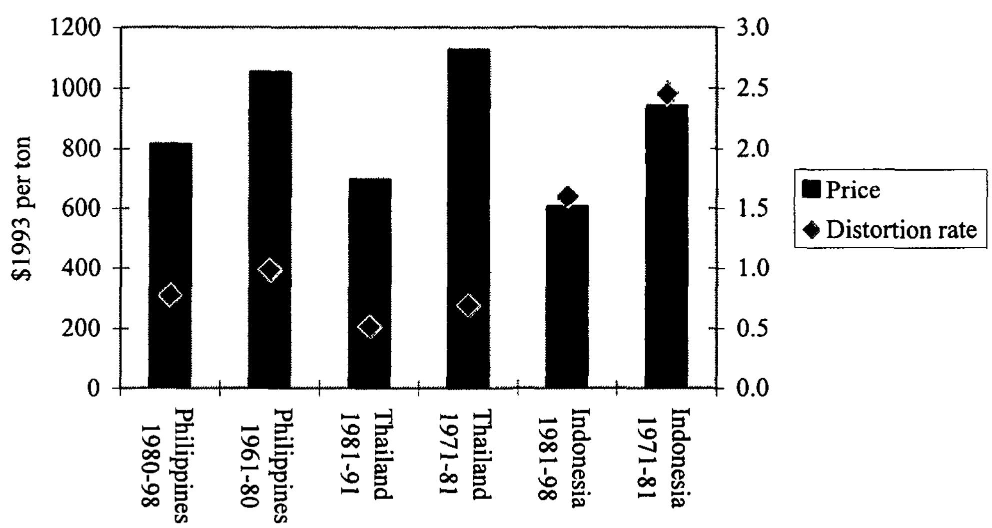
Note: The marginal productivity values are derived from the production-function parameters. See the discussion relating to table 1.4.

Figure 1.9 Marginal productivity of rainfed land



Note: The marginal productivity values are derived from the production-function parameters. See the discussion relating to table 1.4.

Figure 1.10 Distortions in fertilizer markets



Note: The distortion is given by the partial derivative of the fertilzer variable in the estimated value-added function. The distortion rate is this value divided by the market price of fertilizer.

Figure 2.1 Selected Thai variables

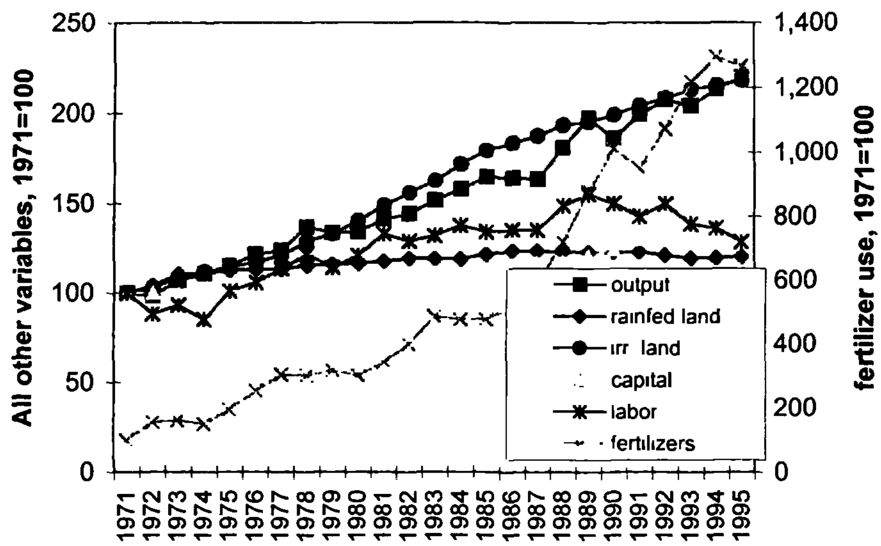
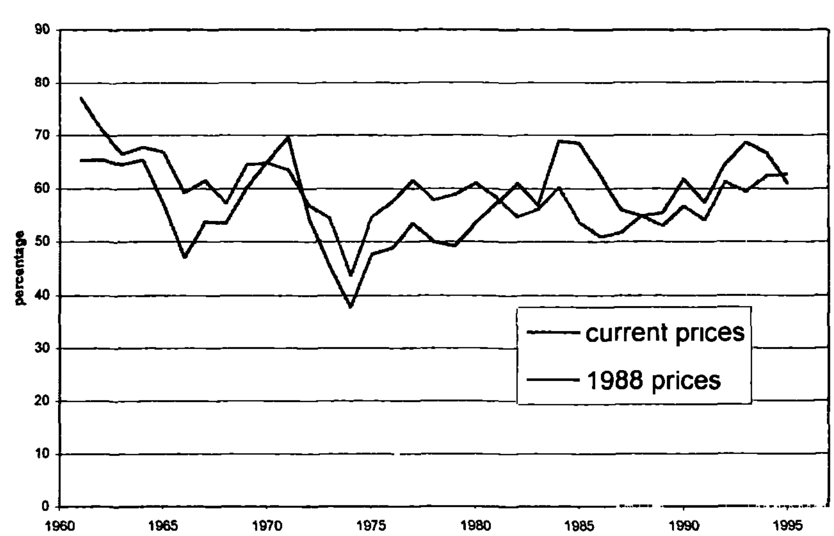


Figure 2.2 Labor share of agriculture GDP



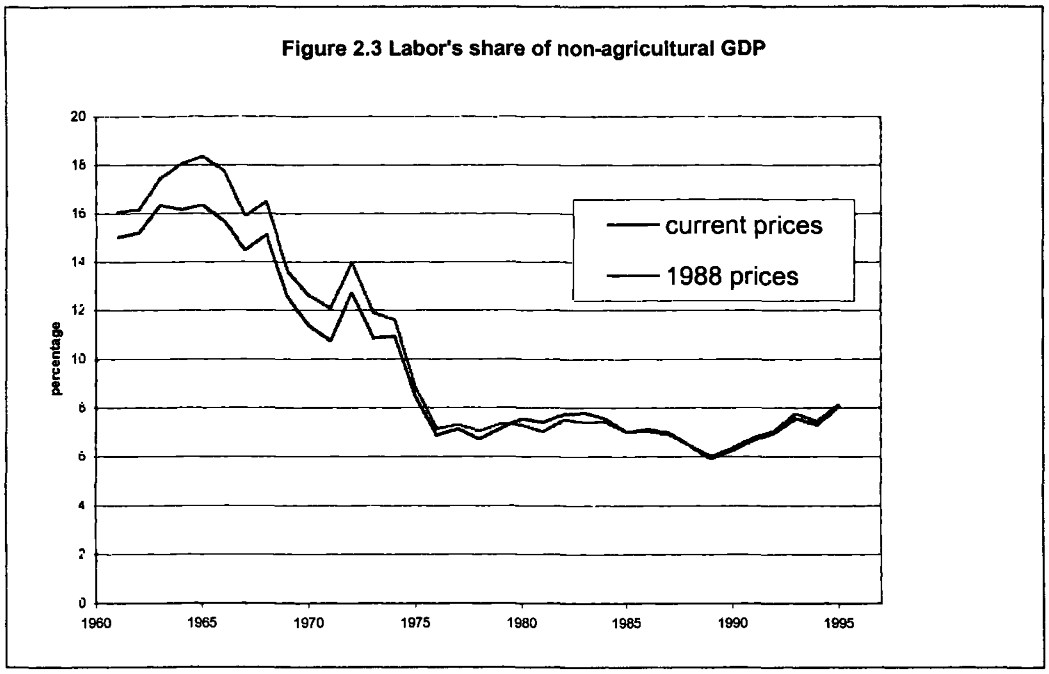


Figure 2.3 Labor's share of non-agricultural GDP
current prices
1988 prices
percentage
20
18
16
14
12
10
8
6
4
2
0
1960
1965
1970
1975
1980
1985
1990
1995

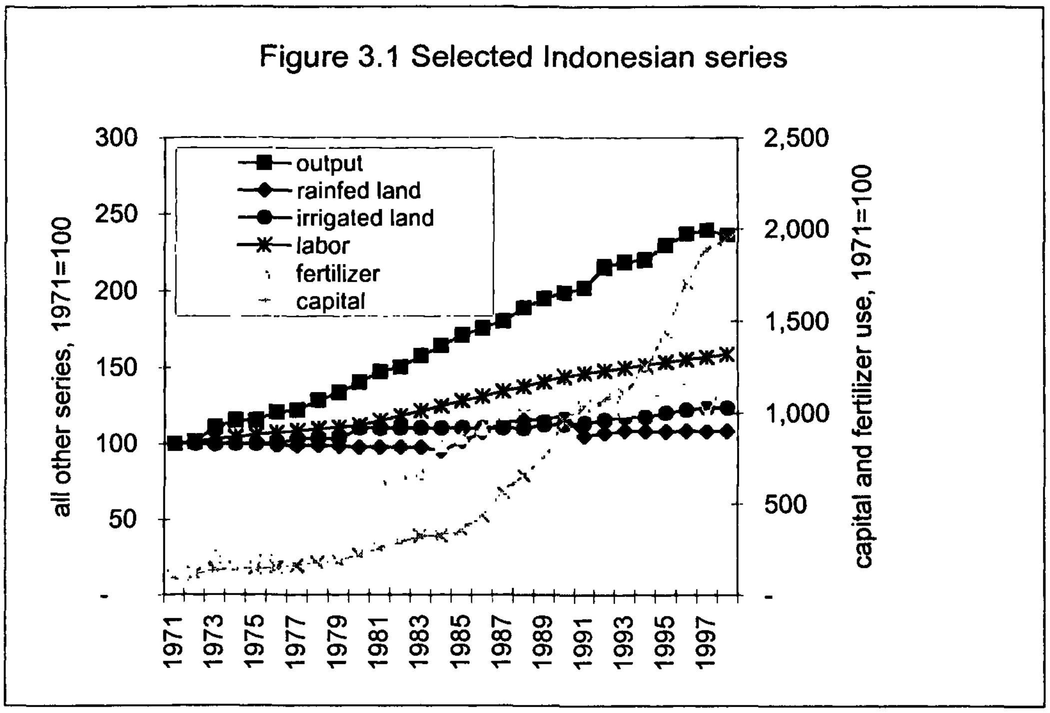


Figure 3.1 Selected Indonesian series
output
rainfed land
irrigated land
labor
fertilizer
capital
all other series, 1971=100
capital and fertilizer use, 1971=100
300
250
200
150
100
50
-
2,500
2,000
1,500
1,000
500
-
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997

Figure 3.2 Ratio of approved investment to GDP in agriculture, forestry and fishing

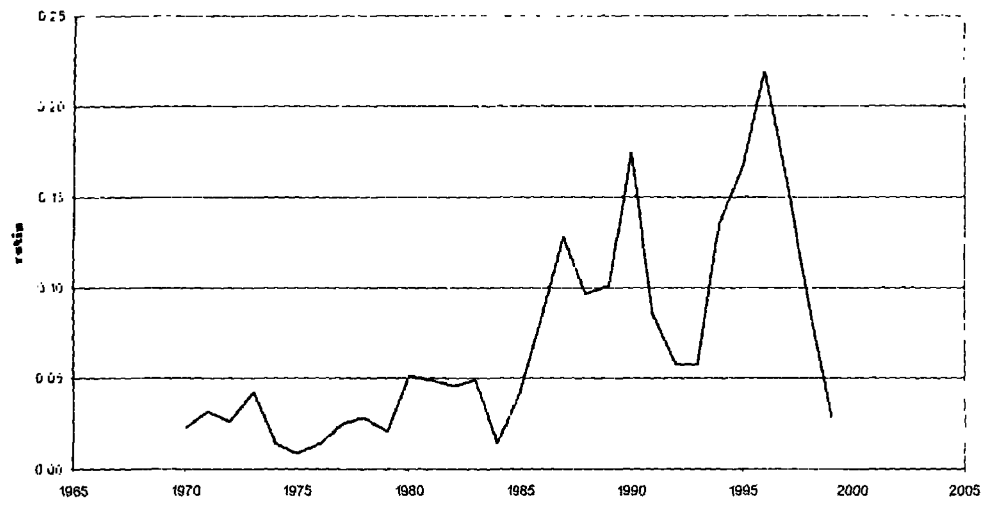


Figure 4-1 Selected series for the Philippines

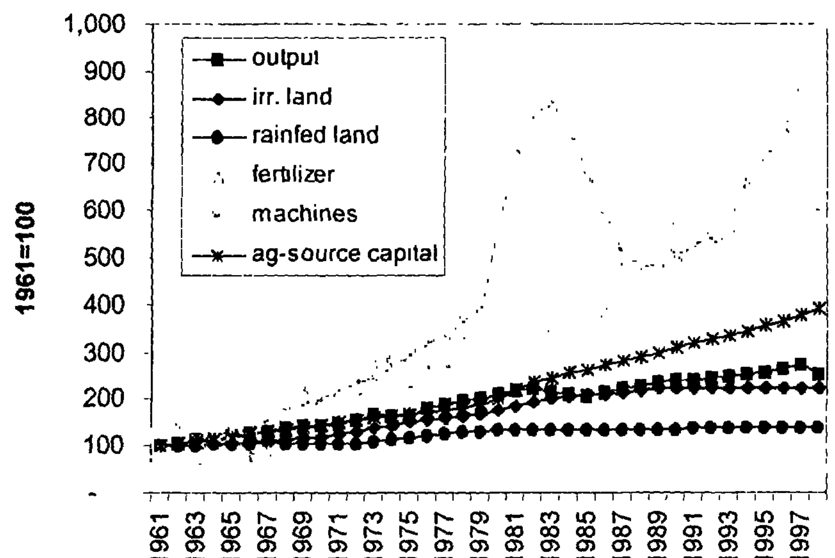


Figure 4.2 Philippines Agriculture Labor Share

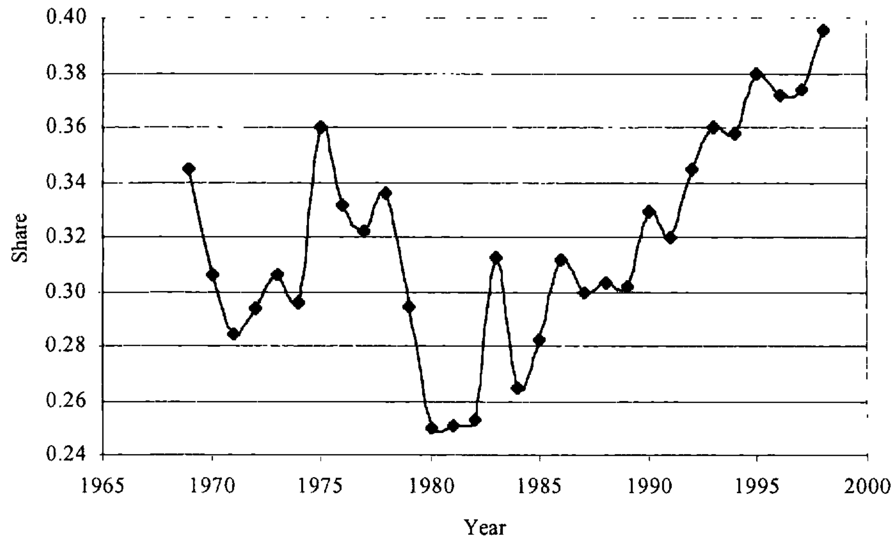
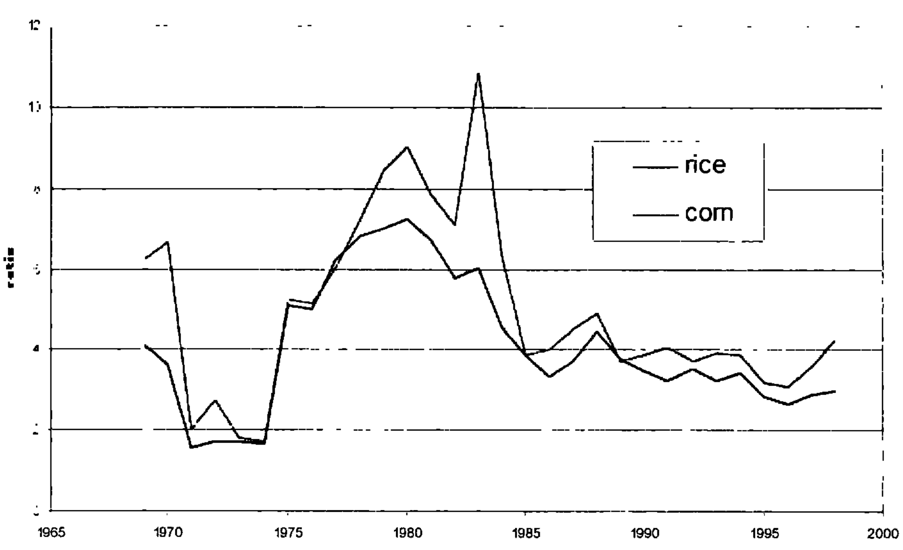


Figure 4-3: price ratio fertilizer to crops



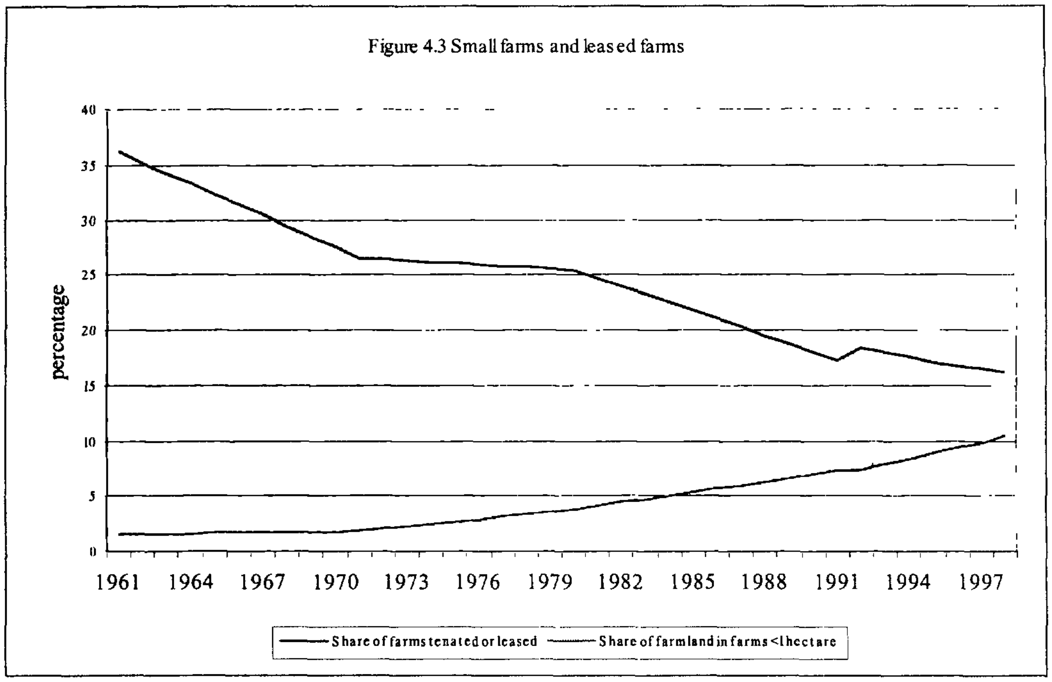


Figure 4.3 Small farms and leased farms
percentage
40
35
30
25
20
15
10
5
0
1961
1964
1967
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
Share of farms tenated or leased
Share of farmland in farms <1hectare

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